ATOMIC MEDICAL PROBLEMS

JEWISH HOSPITAL, BROOKLYN, NEW YORK

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1 When one undertakes to speak of Atomic Medicine in this day and time, there is indeed cause for concern if not trepidation. Few fields of human endeavor are more extensive, more frought with life and death concerns, more overwrought by great hopes and fears, more bedeviled by extremes of pessimism, optimism and sensationalism and more confused by contradicting prophesy.

2 My efforts this evening will then, I think, be most profitably employed in attempting a fair appraisal of this area of medical concern and I hope for your indulgence if the presentation is more sober than pyrotechnical.

3 We love to speak of the "Atomic Age" and indeed one could readily ~~some enthusiasts accounts~~ gain the impression that we will soon have everything powered by nuclear reactors, cure all disease by radioactive isotopes and bring on the utopian millenium. One might also take the reverse course and ~~Others~~ forsee all creation devoted to early extinction by atomic weapons and radioactive contamination. ~~What is one to believe?~~

insert

4 Atomic Medicine is not brand new, but really had its start and a most enthusiastic one over 50 years ago. ~~As you know that start and the substantial application to therapy that resulted, related largely~~ with X rays ~~to~~ Radium ~~which has become quite familiar to us throughout our careers,~~ in quite well standardized applications. Some years later radioactive phosphorus made its debut, but the great modern efflorescense of interest and concern dates from the staggering and disconcerting scientific discoveries and developments that have mushroomed like the

cloud of the atomic bomb, since the discovery that U235 could be fissioned.

The careful studies of ~~Halm~~ Hahn and Strassman in Germany showed in 1939 that uranium which had been subjected to bombardment by neutrons (in hopes of producing heavier elements by addition) yielded traces of lighter elements such as barium and krypton. The weights of these were such as to indicate that some of the uranium atoms were splitting into fragments.

To a few scientists the news of this work was stupendous in its impact; to most of us, I am afraid the news would hardly compare in interest to a few home runs on the ball park or a first down by our favorite football team. Not to cavil at this, for after all a healthy interest in sports is indeed necessary to national vigor, I suspect, nevertheless, that we are often as poor judges of what is really important as the old darky servant in the recitation made famous years ago by the comedian Nat Wells. "No News" or "What Killed the Dog". It appears that the master returning from a solitary vacation, during which in accordance with his doctor's orders he received no news of any kind, was met by his old servant at the train. He promptly inquired for news. The reply was, "No sir, Boss; dere ain't no news; no news a'tall". ~~Then~~ At length after much urging, the servant came up with the recollection that the dog had died. ~~From thence the story~~ This story is one that unwinds backward ~~bit by bit~~ until it turns out that ~~the~~ The dog's death was the end result of a grotesque series of calamities far transcending in importance the end of the unfortunate canine. The ~~particular~~ cause of death, I might add, due to was gorging himself on burnt horse flesh derived from a fire which destroyed the whole of his owner's estate. point

The analogy as regards nucleonics is very rough ~~and in reverse:~~ approximately

The story of fission does not unwind backward exclusively into calamities; and it now ~~but~~ is being unrolled from the scroll of the future along lines both of catastrophic potentialities and of constructive research and useful application. At all events, we find ourselves in this modern age, blessed or afflicted, or both, with nuclear reactors, atomic bombs, and finally radioactive isotopes in great quantity and profusions; ~~and around~~ We are also on the threshold the ~~corner is~~ of utilization of nuclear energy for power.

This is truly ~~prodigious~~ amazing and seems all the more dramatic in contrast ~~by consider-ing~~ to the quiet and unobtrusive beginning in the seclusion of a laboratory where two workers wrinkled their brows over the perplexing results of bombarding uranium by neutrons, ~~finally recognizing that the uranium was undergoing fission~~. insert

It would be fascinating to follow ~~the details~~ history & development further but it would also exceed our time and purpose. I would only note here that present prospects for conventional power applications do not relate to wide or universal use, but rather to special circumstances where the use of customary fuels is difficult, expensive or limits operational possibilities; Hence the interest in applying atomic power in submarines. ~~However,~~ Our main purpose here tonight is to take a glimpse at biomedical implications. omit

Those can be divided into three main groups: I. Those related to atomic warfare; II. Those related to the use of radioactive isotopes in clinical therapy and research; and III. Those related to fundamental research into the biological effects of ionizing radiations.

As we begin to consider these, it might be noted that exception is sometimes taken to the term "atomic" as not being scientifically accurate, since this term could be applied with good reason to ordinary chemistry. Nonetheless, the term is generally applied to phenomena related principally to nuclear and atomic physics, and I hope I may be forgiven for using the term in this popular though rather loose and broad sense; also it sounds rather formidable to many of us to speak of something like modern biomedical aspects of nucleonics and the ionizing radiations. Possibly it is because many scientific works relating to these subjects are highly technical and very difficult for many of us to get much out of. OMIT

I. Atomic Bombs

~~At any rate, we find ourselves with~~ The atomic bomb ~~which~~ has not only given our enemies cause for serious cogitation ~~- to put it mildly -~~ but proven not a little disconcerting to our own aplomb. ~~There are many problems of the gravest sort that we are all very personally and vitally concerned with.~~ The fate of each of us as individuals as well as The future of our country ~~is~~ are at stake ~~and the survival and health of perhaps millions of our citizens.~~

It is tempting to entertain the thought that fears of retaliation may prevent use of atomic weapons, as happened with chemical warfare in the last world war. It would be most reckless and perhaps fatal to bank on this. ~~Certain~~ many of our cities present very profitable industrial targets or constitute vital nerve centers, one or both; so the temptation is there and we ~~should~~ must make sensible preparations. That doesn't mean we must ~~proceed to~~ decentralize ~~rapidly~~ at once all industry at a cost estimated at 300 billion omit

dollars aside from losses due to lowering production and efficiency. We can, however, proceed along such lines as we go, and in addition build more sturdily and with an eye to fire hazards. This will pay dividends too in better living conditions and lessened urban congestions. Disaster planning too, has great peacetime value since periodically we have great numbers of casualties from fires, explosions, wrecks, hurricanes, earthquakes and other misfortunes.

As a weapon of destruction the atomic bomb rivals but so far has not exceeded the results of area or saturation bombing by the more conventional means of fire bombs and high explosives. The difference is derived from the fact that a single bomb accomplishes the destruction instead of hundreds, and defense is thereby rendered more difficult. On the other hand, atomic bombs are scarcer and more expensive, and the stock must be husbanded and expended with greatest care.

The pattern of planning for and coping with any disasters resulting from their use against us, should then follow largely that already developed in England and Germany, and involves such things as the necessity of bringing help in an orderly and coordinated fashion from surrounding areas; firm, definite and well understood provision for controls and exercise of authority; designation and equipment of medical facilities for care of evacuated casualties and refugees; arrangements for rescue parties, equipment and transportation; policing and fire control; indoctrination of populace, etc. The similarity in problems is also accentuated by the fact that the casualties will be preponderantly of the familiar type, i.e. burns and various crushing injuries and

resume with new ¶

and lacerations from falling buildings and flying fragments. ~~However,~~ Finally the new factor of radiation casualties must be added as a most serious consideration, psychologically as conducing to panic, and concretely as adding to our medical burdens. There has perhaps been a tendency to over-emphasize radiation effects because of their ~~unfamiliarity~~ novelty and a peculiar aura of dread. Yet, it is also easy to under-emphasize. It is, I think, best and most realistic to let the facts speak for themselves. It is probable that 20% of all casualties from an atomic bomb will show radiation effects, ranging from mild to fatal, and that 10 to 15% of deaths will be due to it directly or indirectly. This is a quite significant increment and these thousands of added casualties involve heavy strains on hospital and other medical services at a time when they are sure to be already overburdened. To this must be added some peculiarly adverse morale factors.

Fears of sterility, impotency, and other genetic effects are involved. These have been increased by exaggerated accounts and horrifying rumors that go far beyond reality, and call for widespread educational efforts to bring these features into proper perspective. A second demoralizing feature is the occurrence of thousands of cases of severe illness after a period of comparative well being, during which the victims may scatter throughout surrounding areas. As these cases fall ill, alarm and panic may be spread. This lends point to efforts to provide some type of surveillance over potential cases of radiation illness, aside from purely therapeutic considerations. A third feature is inherent in the pattern of clinical effects which, in serious cases, are bizarre, protean, difficult to handle, and make a very ugly picture what with

infections, hemorrhage, ~~G.I.~~ gastrointestinal disturbances, epilation, and severe prostration. Finally, there is not a little of the exaggerated dread that tends to be associated with the mysterious and is akin to the uneasiness many people feel walking by a lonely graveyard at night. Thus the overall burden from radiation effects is, if not the major concern, a severe and thoroughly unwelcome turn of the screw. Nevertheless let us always remember that at the onset, our main preoccupation must be with the more familiar problems of rescue, evacuation, and treatment of burns and trauma. An important point ~~here~~ to remember is that in an air burst, which is by far the most likely mode of attack, there need by no fear of radiological contamination of serious degree, beyond the zone of total destruction and rescue work can be begun at once and without fear.

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In the case of an underwater burst there will, of course, be heavy contamination, ~~but here too, we should recollect~~ However, ~~can~~ recalling that most fission products which produce that contamination decay rapidly, ~~so that~~ we can profitably encourage ~~some~~ delay on the part of people emerging from shelters or attempting rescue. It will pay large dividends. Radiological surveys along with proper indoctrination are necessary here if we are to calculate promptly requisite time intervals for all concerned, exercise effective control, and thereby minimize casualties and panic ~~as well~~.

Radiological Warfare should be mentioned before leaving weaponeering aspects. In popular accounts, Radiological Warfare has been featured in hair raising fashion as a quick and efficient lethal agent. In reality it presents many difficulties as noted. It is expensive, slow in effect and impermanent. So let us look at the matter a bit closer. In the report of the Secretary of Defense, way back in July 1944, ~~we find the following~~:

(a) "It may have the capability, if used in large enough quantities, of denying the continued occupation (although not temporary access to nor transit) of the target area for a selected period of time without destroying the facilities in that area. This would be useful in denying enemy use of friendly areas which might have to be evacuated, or in forcing the enemy to evacuate his own facilities without destroying them.

Omit the page

(b) It has a characteristic of compactness, which increases the flexibility and reduces the cost of delivery.

(c) At present, it is a 'mystery weapon' and proper use of psychological propaganda might have great effect on poorly informed people. For this reason it is vitally important that the people of the United States be properly informed concerning the defensive aspects of RW, so that misinformation cannot cause panic.

In general, the disadvantages would appear to be

(a) The continual radioactive decay of RW agents in storage, which requires continued discard of old agents and replenishment of the stockpile.

(b) If RW materials are produced as a result of irradiation of special materials in a reactor, the use of RW must compete with production of other atomic weapons. If the radioactive products resulting from fission are to be used, to avoid competition with other atomic applications, there are other extremely difficult and costly problems to be faced, not the least of which is the separation of desired agents from the complex.

(c) The fact that these RW agents are constantly emitting dangerous radiations makes it imperative that shielding be provided to prohibit exposure of the preparing and delivering personnel to the injurious radioactivity.

(d) ~~The~~ limitation on the use of RW in tactical situations, because of the delay in appearance of casualties, ~~has been previously discussed~~.

(e) From practical standpoints the problem of delivery and proper dissemination is probably the most difficult problem to overcome."

This is followed by a discussion of radiological effects in Japan and Bikini and why certain contaminated ships were sunk. These reasons relate to obsolescence of the target ships concerned, costs of repairs and long distance towing, decontamination, etc., as compared to the scrap value. The section concludes with this paragraph:

> "It would appear extremely difficult to concentrate on attack by RW agents over any considerable area to such an extent as to cause serious injury from a short exposure. It is possible that more casualties would result from continual radiation. However, these areas would probably be evacuated. The evacuation areas would be determined by monitoring groups using instruments developed to indicate the presence of radioactivity. In this respect the Department of Defense is attempting to develop simple, rugged, reliable instruments for detecting radiation which are capable of being mass-produced for use in the field. Prior to evacuation, protection can be gained by seeking shelter inside the most heavily constructed buildings and closing doors and windows to prevent entrance of the radioactive materials."

This gives the general picture. It is of interest to relate a few more details.

As noted in "The Effects of Atomic Weapons" (page 287), radioactive material can be obtained from fission products formed in the pile or by purposeful irradiation of elements placed in the pile. A nuclear reactor in the course of 100 days (million watt output) might produce about one megacurie of activity. This spread over a square mile could produce 200 r/day of 1.5 gamma at 3 foot level .... (gamma ray should be the most effective radiation to use).

It is easy to see that it would not be simple to use nor too cheap.

The manner of use is usually conjectural as being in the form of death sand prepared by drying solution of fission products on very fine sand or metallic powder, which would not be readily detectable as it settled.

In general, advantages would relate to denying an adversary unrestricted use of ~~limited~~ certain areas or facilities for ~~a~~ time, ~~compactness, and most important of all and as already mentioned,~~ causing interruption of work, possibly producing ~~and production of~~ panic, & finally causing forced frank disadvantageous....

These ~~Disadvantages~~ relate to ~~decay~~ limited half life, with ~~and~~ resultant difficulties in stock piling; ~~difficulties in~~ separation of ~~most~~ desirable fission products; shielding ~~of~~ personnel charged with ~~responsibility of~~ delivery; diversion of pile function from production of fissionable materials.

If we are well indoctrinated and prepared, RW should be capable only of a ~~can have only a serious~~ nuisance value. However, ignorance and unpreparedness ~~which conduce to~~ could well permit/lead the door to panic ~~can make possible~~ and ~~much more~~ serious interference ~~effects~~.

With this brief mention of some of the problems related to bombing let us pass on. } omit

II. Radioactive Isotopes

The consideration of radioactive isotopes is a much more agreeable field which we are now becoming quite familiar with. ~~One after another~~ many of our principal hospitals are installing isotope laboratories, as ~~so as to make possible the use of~~ I^{131} */ and P^{32} **/. The clinical fields of usefulness of these ~~are~~ become well delineated~~; and it also appears generally recognized that there must be regard for careful selection of cases~~. In addition to these rather familiar isotopes, it is worthy to note that Na^{24} ***/ is frequently helpful in studies of circulation, Fe in studies of Hgb & RBC. ~~Proceeding to some less familiar elements, it can be mentioned that~~ (a) Ga^{72} ****/ shows promise of providing diagnostic aid in osteogenic tumors - this by reason of selective

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*/ I^{131}, 8d; $B^{-}0.6$; γ 0.36
**/ P^{32}, 14.3d; $B^{-}1.7$
***/ Na^{24}, 14.8h, B^{-} 1.4; γ 1.5; 3.22
****/ Ga^{72}, 14.1h, $B^{-}0.8$; 3.4; γ 0.6; 2.5

uptake by such tissue. It may also prove of therapeutic benefit. I might note that the initial work on this isotope was carried out in Bethesda at the Naval Medical Research Institute and the Naval Hospital. The work is now being followed up in the new cancer hospital at Oak Ridge as well. (b) Radioactive gold (Au^{198}) */ shows promise of being useful in certain malignancies by the mechanism of local injection. (c) Co^{60} **/ promises to be of great help whenever gamma rays of about 1.1 and 1.3 MEV can be used. So called Cobalt bombs may be constructed as well as small applicators. It may well be that Cobalt can be used to provide a useful and convenient source of rays roughly equivalent in its effectiveness and mode of action to the million volt x-ray generators. General Electric Company recently exhibited apparatus of this type and it should soon be available.

In passing one can note two features that are well to bear in mind. The first is that although it seems ridiculously easy to administer radioactive isotopes, the associated problems of selecting the cases, providing for reasonably accurate dosimetry, and meeting the requirements of radiological safety, are difficult and demand great care, thought, specialized experience and proper equipment. The second is that although much may be expected from the therapeutic use of isotopes in malignancies, it is not likely that we will find a panacea in them. The limitations involved by degree of selective uptake, toxicity of materials and radiation effects on normal tissues, are not likely to be overcome entirely.

It is probable that another field of utility may in the long run pay bigger dividends, and that field is the one of tracer application, whereby various elements can be followed through the intricacies of

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*/ Au^{198}, 2.7d, B^{-}0.8 γ 0.28, 2.5
**/ Co^{60}, 5.3y, B^{-}0.3 γ 1.1; 1.3

metabolism with a precision that heretofore was beyond us. By this type of employment, we are beginning to get down to the bedrock of biochemistry, and we will gradually come to know much better all phases of metabolism, including that of tumors and what controls growth and repair, and what goes wrong when cells go wild.

The phases and types of such tracer work are innumerable and one could spend hours merely cataloguing them. The August, 1950 issue of Nucleonics */ lists a most imposing array of biological syntheses of tracer compounds in connection with metabolic studies. It is beyond the purpose of this general account to go into details, but it is appropriate to mention two general features which provide a basis for interesting possibilities. One is that the turnover of various materials in the body appears much greater and more rapid than heretofore believed. The other is that it appears that certain chemical bonds usually conceived of as firm and closed, on the basis of conventional studies, are actually open in the living cell. In general, our chemical factories and living membranes are busier and doing more intricate work than we thought.

III. Basic Phenomena

As we come finally to fundamental studies of the biological effects of ionizing radiation, we find a fascinating field in which we are gradually achieving a much better understanding.

Just how the ionizing radiations produce their effects on living tissue has been a dark, mysterious affair. Until recent years most of our knowledge and most of our preoccupation too, has been related to

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*/ Woodruff, Nathan H., and Fowler, E. Eugene, Biological syntheses of radioisotope-labeled compounds. Nucleonics 7: 26-41, August, 1950.

histopathological changes. Now, however, some light is being shed on the reasons behind the changes we see in our microscopic slides.

The fundamental, though not exclusive, basis for biological action is, of course, ionization. This ionization is not like that we know of in the ionization of electrolytes in solutions where we find charged atoms and radicals, although such may result secondarily as we shall see. Here the individual atoms are primarily affected. High energy photons, such as comprise certain gamma rays and therapeutic X-rays, act as minature bullets which dislodge orbital electrons leaving the atom with a positive charge and thus forming an ion pair comprised of the electron and the atom it was forced from. The electron is set in motion - often a rapid one - and in turn dislodges other electrons to form still more ion pairs. If an electron itself is the initial primary ionizing particle (as in the case of the Beta ray), it serves in the same way. So do the proton and alpha particle. Indirectly the neutrons also cause ionization. The net result, in any event, is a flux of dislodged electrons and a residue of charged atoms. Difference in the effects of the various radiations are related to the penetration and to the density of ionization.

The biological importance of all this is that the atoms affected by ionization are prone to effect chemical changes. In addition, whenever a binding electron is dislodged, there will be disruption of the molecule concerned. In the case of solutions, both the solvent and the solute will be involved and often the effects on the former will be more important. Thus it becomes very appropriate at this point to consider water since it forms such a large part of protoplasm. We find as a result of this ionizing process that instead of the usual combined molecular forms, we

have a number of hydrogen and oxygen atoms and also OH groups usually ionized for a time. Traces of hydrogen peroxide and possibly organic peroxides appear. Aside from these effects on water and its dissolved gases, there will of course be direct effects on electrolytes, such as the halides. These are also subject to the effect of ionization and all the various components of living tissue may be directly affected in greater or lesser measure on a statistical probability basis related to the amount of radiation and molecular size. Then, too, we must remember that aside from ionization there is some degree of excitation whereby atoms are raised to a higher energy state than normal without loss of electrons. This too will encourage chemical changes and tissue reactions such as we are familiar with in the case of ultraviolet light which in great measure produces excitation rather than ionization. All this sort of thing interferes with the normal metabolic processes by producing changes which may be minor and in some measure reversible in the case of small doses, but major and irreversible with sufficiently large doses. Upon this quantitative consideration the fate of cells concerned will naturally depend. The sort of changes that take place are about as follows: Proteins are denatured; enzymes are inactivated; cell respiratory exchanges depressed; mitosis diminished, disordered or interrupted; chromatin patterns disturbed; chromosomes broken or distorted; the catalytic activity of genes depressed or stopped. Some genes are destroyed as functioning agents and in general there is an increase in genetic mutations of all types.

This matter of genetic mutations from radiation has been and still is the subject of innumerable studies but we are yet far from the

precision we would like for the human species. Quantitative results as applied to the human species involve many extrapolations and estimates vary widely. However, as a rough guess it appears that there is probably about a one per cent increase in the liklihood of transmitting an unfavorable mutation for each 100 r received. Thus a basic consideration should be that since most mutations are harmful, unnecessary or reckless exposure is certainly something to be avoided.

Quantitative data are often interesting and in this instance, throw additional light on the biological mechanism of radiation injury. We can start with the relative numbers of atoms concerned. One r unit produces about 1.6×10^{12} ion pairs per gram of tissue. That sounds like a lot but then take a look at Avogadro's number, which is the number of atoms in a gram-atom (one gram for each unit of atomic weight). It is 6.1×10^{23}. Thus only one atom in many billions is affected by such a dose. Again it has been calculated that 1000 r produces changes in only one out of 10 million molecules. Accordingly one may well speculate as to how anything of importance can happen at all in living tissue except with fantastic doses. Yet, it appears that 600 r would almost invariably prove fatal to a human being. What is indicated by this is that radiation must throw a small but very potent monkey wrench in the metabollic machinery. Protein molecules and such structures as genes are of enormous molecular weight, so that the effect of one ionization instead of being limited to one molecule of water may serve to inactivate a biological unit some hundreds of thousands in molecular weight. In this way we can begin to see a basis for the disproportionate effects especially when we consider that certain of these molecules may

be vital functional units; and perhaps at this point one's speculations are apt to take the opposite direction and the ordinary exposures of clinical radiology seem alarming. One can say that there is no cause to worry about the exposures in clinical radiology, when subject, as they normally are, to supervision by qualified radiologists; or again of receiving a limited amount of radiation in connection with special activities, once more when subject to proper dosimetry and control.

This brings up the matter of permissible dosage, which is a lengthy and difficult subject in itself. Suffice it to say here that the usual limit of 0.3 r/week has been derived largely with reference to long time workers in the field who are continuously exposed to hazards of radiation. Clinical exposures, and in general those in the occasional category, call for different criteria related to practical therapeutic or operational needs. An important basic consideration in such matters is the total life-time cumulative dosage that can be considered relatively inocuous. This is still uncertain, but we do find that experimental animals receiving substantial daily doses over long periods show an increased rate of aging at about the 1000 r level, and that there is also a carcinogenic effect. Radiologists have shown a significant increase in the incidence of leucemia as compared to the general population, although the dosage factors are unknown and the number of cases small. Genetic effects are unfavorable as already noted. Thus, if one is to hazard a guess as to a permissable life-time maximum, it can only be a tentative one; on such a basis perhaps 300 r would not be too far from the mark as an average and with the expectation that the greater part of this amount should not be antecedent to the reproductive years.

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In this regard one can add that recent studies indicate greater vulnerability in the first 6 weeks of gestation. Thus when there is possibility of pregnancy, elaborate studies of the pelvis should be avoided.

Returning from this digression to the problem of basic mechanisms, let us particularize a bit: The effects of noxious agents tend to be greatest and certainly most important where there is active biochemical commotion involving compounds of labile nature, and so it is understandable that there is a disproportionate effect on enzymes and actively growing or multiplying cells or tissues, such as blood forming cells, gonads, germinal layer of skin and muccous membranes. Secondarily there are toxic effects probably related to denatured proteins, aberrant functioning, and products of injured or dead cells. There are also reactions, resembling the effects of histamine and forming the basis for a very plausible hypothesis that the formation of histamine-like substances comprises another basic phase of radiation damage, perhaps as part of an "alarm reaction". Finally there are the manifold complications resulting from pancytopenia, ~~in case~~ These are usually the cause of fatal outcome as of course is well known. ~~Again in severe radiation illness there is some suggestion that a herpanin-like substance may play some part in the hemorrhagic syndrome, although it appears now that the thrombocytopenia is the main causative factor here.~~

Resume

The various toxic phenomena naturally bring up the matter of therapy and the possibility of antidotes.

In the nature of things the ionization itself cannot be presented; nor can the immeidate effects of the toxic substances be neutralized with sufficient promptness after the event of exposure.

Suppose, however, we anticipate the impact of heavy dosage of ionizing radiations by administering certain substances. The picture then is altered since there may now be diffused throughout the tissues, compounds which can compete with the vital living structures for

combination with toxic agents concerned. Thus we find that if there is a liberal amount of sulfhydryl-containing agents, such as cysteine or glutathione, that lethal effects are reduced roughly by a third. Curiously enough, a most toxic substance, sodium cyanide apparently exerts a protective influence. One-tenth of a mgm (0.1) injected into a mouse intraperitoneally has been stated to have beneficial effects on a resistence to lethal dosages. Again cortical adrenal extracts and desoxycorticosterone have shown beneficial effects.

Application of such agents is naturally limited in scope and their prospective use quite conjectural. Nonetheless, the picture is not too grim. There are other features that lend encouragement to therapeusis.

A very encouraging feature is that certain primordeal cells are resistant, possibly because their activity is not consistently at high pitch. However, whatever the reason may be, the fact remains that the so-called stem cells found in gonads and in blood forming tissues are resistant. Thus, if we can tide victims over the crisis of pancytopenia with its attendant anemia hemorrhage and loss of resistance to infection due to agranulocytosis, these cells will make possible a "come back". So if by good nursing care and possible use of transfusions and antibiotics, we can tide apparently hopeless cases over the emergency phase, they will have a good chance of regaining virtually normal health. This is indicated too by the present good condition of many former Japanese casualties. Possibilities of extremely helpful nature are also in sight from developments of blood substitutes, notably Dextran.

With this it appears time to bring this sketchy summary to an end, and I would like to do so by suggesting that we do not be too defeatist and pessimistic in our attitude towards either the radiation effects, or the other hideous aspects of atomic bombs. We are not helpless and even if worst comes to worst, let us remember that the world has survived worse and more terrible events, as when calamities such as the "black death" left all of Europe and England little more than graveyards.

There is no reason to believe that we will even approach such complete devastation, but let us remember in any event that with the vision that should characterize free people, we must not place these physical hazards foremost. Rather, let us have regard above all else for our freedom and self-respect. Without this, we are contemptible and not worthy of survival. With them, we can, with courage and determination, be invincible.

It is now time to bring this summary to its end and I would like to close by saying that we must not become defeatist and pessimistic in our attitude toward modern weapons. We are not helpless and it is interesting to go back some years and read in contemporary accounts of the San Francisco earthquake and fire, how promptly things were gotten in hand. It is true that casualties would be on an unprecedented scale in this day and age but we are also becoming much better organized and capable of dealing with such.

Let us keep up the good work now going on and remember that our country has withstood tough shocks in the past, can do so again if need be. Neither we nor civilization are going to perish and I believe our country can and will remain the great citadel of freedom and opportunity it has always been.

MEDICAL ASPECTS OF RADIOACTIVE ISOTOPES

FRANCIS DELAFIELD HOSPITAL
New York, New York

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RADIOACTIVE ISOTOPES

Francis Delafield Hospital
New York City
13 Nov 1951

Lecture Notes
Nov. 1951

MEDICAL ASPECTS OF RADIOACTIVE ISOTOPES

When we speak of isotopes in these present times we have in mind radioactive isotopes and likely enough many people ~~probably~~ associate magic possibilities with them. Surely the term isotope is now one to conjure with: It is no longer a recondite term employed by chemists and physicists for their own obscure purposes and perhaps to plague and mystify their hopless ~~hapeless~~ students. Now it may savour of the sacrilegious to seak of magic possibilities to a scientific minded medical audience, But all of us, scientists or not, are apt to overindulge in extravagant hopes and in all truth such extravagant things have happened in the past decade that we can all be pardoned for becoming a little dizzy in the head and expecting most anything including a little dash of magic. Well perhaps we have that too because our physicists have outstripped descriptions and imaginative visualizations. Things happen in amazing and peculiar ways and we learn of physical laws never dreamed of before and at times transcending the power of human description or comprehension.

It seems that much of this newer physics relates to radiation, isotopes and transmutation of elements. The story began or rather emerged from the laboratories very spectacularily with Roentgens discovery of the x-ray followed by Becquerel's discovery of natural radioactivity and very soon the isolation of Radium and Polonium by the Curies. And I might add that all this caused very nearly as much astonishment, bewilderment and sensationalism as the atomic bomb in our own times.

Francis Delafield Hospital
13 Nov 1951

The study of radium and related elements made us acquainted with new and mysterious radiations and taught us that certain elements were going through progressive transmutations eventually reverting to Pb. insert (1) We also learned that enormous energy was being released. At about that time too (1905), Einstein startled the scientific world with his relativity theory and related thereto the equivalence of mass and energy $E = MC^2$.

That was startling indeed but no one could find a way of tapping or rather controlling nuclear energy and things gradually simmered down to the familiar pattern involving the use of radium and a few other radioactive elements.

Then came the modern efforescence of interest and concern dating from the enormously stimulating scientific discovery of fission by Hahn and Strassman. The families of heavy radioactive elements had been known for years and along with it the fact that transmutation of elements occurred. The thing was, how would we accomplish and control transmutation ourselves?

No ordinary methods had sufficed to modify in the slightest the rate of decay of radioactive elements. How, however, the fact that a flux of neutrons could bring about nuclear fission and also numerous transmutations became the key to the whole business via the atomic pile and led eventually to the production of radioactive isotopes in liberal quantities in nuclear reactors or piles. ~~and~~ On a smaller scale in particular accelerators, various isotopes can also be made by so called atom smashing techniques.

It also led, of course, to the atomic bomb, but on this occasion I will dodge that matter. Usually this is difficult to do and I begin to find myself in regard to that subject like a certain character in Charles Dickens' novel of David Copperfield. This poor fellow was writing or attempting to write a history of England - but he could never get past the head of Charles I, that unhappy monarch who was beheaded by his bold and ruthless opponent, Oliver Cromwell. Well, of course, once you start going into the A bomb business you are apt to get stuck right there.

So then let us look at once into isotopes, what they are and how they fit into the modern medical picture. I am sure you all know the conventional definitions and know that the isotopes of a given element have the same number and configuration of electrons and hence the same number of nuclear protons. They do have, however, different numbers of neutrons in their nuclei and so differ in weight.

Now if this were all there were to it there would be no fireworks but it so happens that the nuclei become unstable when there are too many or too few neutrons and also if there are too many nuclear particles. The ratio of neutrons to protons tend to be low for light elements, 1 to 1.3, and high for the heavy 1 - 1.6. This factor produces some interesting results. When a heavy nucleus is fissioned, then not only will a few neutrons be released but the new fission products will have too many neutrons for stability.

Thus the fission products of an atomic explosion are radioactive and begin decaying at once in what is called fission chain reactions, usually by β decay

and study of these has revealed large numbers of radioactive isotopes.

However, we don't get our isotopes for clinical use by scooping up fission products but by nuclear changes resulting from cyclotron bombardment and still more by far, from subjecting various elements to the neutron flux of nuclear reactors.

There is no need to go into the reactions concerned in detail. Instead let us look at what happens to unstable nuclei because that is what we are interested in as we set about to employ radioactive isotopes.

Off hand one might expect that unstable nuclei would simply revert to a stable state without any delay ~~altogether~~ whatever. Instead definite statistical time elements are involved. A given atom may disintegrate at once or perhaps after a million years, but the average rate for the countless billions of atoms involved in our operations is constant under all ordinary circumstances for a given isotope. It seems that some particular arrangement of complex factors must occur before the nuclei can throw off a certain ray or particle. This is elucidated by such studies as quantum mechanics and involves much theorizing which I think we can well leave to the nuclear physicists. Suffice it to say here that is how the atoms behave.

Let us look now at the type of radiation involved and the attendant circumstances. We are mostly familiar with the α, B and γ radiations but they do not end the story. There are positrons, x-rays, ~~and~~ from both ejection and nuclear capture of orbital electrons, neutrons and protons.

The α particles show a mass of 4.0389 and a double positive charge. They are thrown off almost exclusively by heavy elements as is natural considering their ~~might~~ size or mass. The main exceptions are the $4\,Be_8$ and $3\,Li_8$. They are exceedingly unstable and short lived. They simply split in half to form Helium. (Sm^{152} is another; half life 0.93×10^{12}y.)

α particles are exceedingly potent ionizers, 30,000 pair per cm in air, thus forming a dense columnar streak in the Wilson cloud chamber. However they penetrate very feebly and their range in tissue is a matter of 30-50 microns. They do not penetrate the horny layer of the skin and are stopped by heavy paper or thin sheets of Al or lucite. That does not mean we need have no concern about them. Far from it. The heavy α emitters such as Ra, mesothorium, uranium and Plutonium settle in the bones if they gain access to the body and are absorbed. There they are destructive to ~~dainty~~ primitive blood-forming cells and irritate bone, ~~and~~ so that they may cause trouble by bringing on the varying ~~symptoms~~ clinical panorama of progressive pancytopenia and favoring the onset of malignant bone tumors. The dangers are now well known and guarded against.

I might note that α emitting elements such as Radon have appeared to exert beneficial effects on ulcers. It is not clear why this should be - and is somewhat reminiscent of the "hair of the dog that bit you" cure when used in the case of radiation ulcers. It might perhaps be that mechanical stimulations by atomic bombardment might play a part or perhaps some compound formed by transmutation.

At all events we are more concerned with radiological safety aspects of α rays than therapeutic.

BETA PARTICLE β or e^- mass 0.000548 charge -1

These are actually electrons, identical with those from other sources such as evacuated tubes and heated filaments. They differ only as regards velocity, direction and focusing. Energies vary from practically zero to 3 mev or occasionally much higher. An important and perplexing difference from the alpha particles comes to light here. Instead of certain discrete and fixed levels of energy and hence velocity, we have a wide, continuous distribution of energy levels between zero and maximum so as to form a sort of continuous spectrum. This is out of keeping with other types of radioactive behavior and also with the emission of light which, as we know, forms definite line spectra. This dilemma has been solved on a mathematical basis by postulating the existence of another particle, the neutrino.

NEUTRINO

According to this view, for each beta particle emitted another particle, of similar mass but lacking a charge, is also thrust out and the total energy is divided between them on a probability distribution basis. Thus we will find that in some instances nearly all the energy will go to the electron, while in others the neutrino will receive the lion's share; naturally there will be every graduation in between, only the total energy remaining constant. This theory is very ingenious and probably valid, but owing to the slight mass and lack of charge, all efforts to demonstrate the actual existence of neutrinos have failed. Thus, although they are of great theoretical interest, nothing is known of their behavior either physically or biologically.

Returning to the subject of beta particles or electrons, it remains to be noted that they show greater range and penetration but much less ionizing power (75 per 1 cm. air) than alpha particles. They are also readily deflected. Thus a 3 mev alpha particle shows a range of only 1.7 cm. in air, whereas beta particles of similar energy travel about 13 meters in air. An alpha particle is stopped by about 0.06 cm. of aluminum but an energetic beta particle may transverse 1 cm. Beta particles can thus penetrate and damage skin. Nevertheless, they are of most importance when they are given off within the body following the absorption of a beta-emitting substance.

BRAGG IONIZATION EFFECT

The ionization figure of 75 per 1 cm. of air is an average since electrons, and other charged particles as well, show a curious variation in ionizing power, dependent upon velocity. Thus electrons at a velocity of 0.4 that of light, which corresponds to an energy level of 46,000 electron volts, produce 288 ion pairs per 1 cm. of air. As velocity and energy increase, the amount of ionization decreases so that at the velocity of 0.5, that of light (0.5 v/c) and energy of 79,000 ev, the ionization rate becomes 185 per centimeter. A velocity of 0.8 v/c and corresponding energy of 0.34 mev yield 72 ion pairs per centimeter and at a velocity of 0.95 v/c and energy of 1.125 mev we find the rate 51 per centimeter.

The reason for this effect is thought to lie in the assumption that high speed electrons pass atoms too quickly to exert as pronounced an effect as slower electrons. However, with extreme speeds and

energies there is again a slight increase in ionization, apparently dependent upon alteration of the electron's electric field with extension of it at right angles to its path, the result being that there is a slightly wider sweep.

This variation in the amount of ionization is spoken of as the "Bragg Ionization Effect" and the degree as "specific ionization" or "K". Mathematically we find that "$Kt = 46/(v/c)$" where v = velocity of the electron and c the speed of light.

NON-NUCLEAR B RAYS AND INTERNAL CONVERSION

The electrons which constitute beta rays are largely emitted by the nuclei but not exclusively. Those which produce the continuous spectrum and suggest the existence of the neutrino are definitely of nuclear origin, but there are other beta particles which show discrete energy levels and are associated with rays identical with K and L x-rays. ~~Thus gamma rays from Ra^c (bismuth 214) are similar to the K and L x-rays of bismuth.~~ What happens is that nuclear gamma rays sometimes eject electrons from the K and L orbital shells, thus producing at once K and L x-rays and electrons of orbital origin at definite energy levels. The gamma ray may be completely absorbed in accomplishing this, the phenomenon being known as internal conversion.

POSITRON e^+ mass 0.000548 charge +1

These are seen only in the case of certain unstable isotopes, which have the requisite energy (excess of 1 mev) to shift a nuclear ~~[illegible]~~ proton to neutron. They naturally have some ionizing power from their own properties of mass and charge but, ~~as we have already seen,~~ disappear almost

$_7N^{13} \xrightarrow{e^+} {}_6C^{13}$

immediately in annihilation reactions with resultant creation of gamma photons. - Explain + mention pair production with supervoltage x ray

GAMMA RAYS

γ mass 0.00107 at 1 mev. Charge 0

It ~~will be noted~~ is interesting to note that mass is ascribed to gamma rays ~~in the subject heading~~. This is a natural consequence of the particulate behavior these radiations show in certain phenomena. It is also a natural consequence of the energy-mass relationship inasmuch as we have seen that there must be some mass corresponding to the presence of energy levels. Thus not only is it to be expected that radiant energy should show mass effects, but that the greater the energy, the greater the mass. This has been verified experimentally, but it must be pointed out that there are certain differences between the particulate behavior of electromagnetic quanta of energy or photons and that of "true" particles such as electrons, protons and the like.

Explain as electromagnetic waves or particulate photons;
Penetration + range
absorption mechanism
similarity to x ray
Ionization only 1.5 pair per cm.

NEUTRONS

n mass 1.00893

Since neutrons have no charge, one might at first thought suspect them to be relatively innocuous. However, the sad fact is, that, owing to several factors, they are relatively extremely dangerous biologically. Because of their mass, which is about that of a proton or hydrogen nucleus, they have great kinetic energy and, owing to lack of charge, penetrate readily and so reach the nuclei, where they cause ejection of protons from hydrogenous material, and result in the formation of various unstable isotopes. Hydrogen, which is very abundant in living matter, tends to have its nuclei

shot out by fast neutrons to form protons; moreover it captures slow neutrons to form deuterium in which process gamma rays are emitted. Again, in the case of sodium, there is often the reaction: ${}_{11}N_a{}^{23} - {}_{o}n^{1} = {}_{11}N_a{}^{24}$. This form of sodium is radioactive emitting beta particles & γ rays. Nitrogen 14 may become C^{14} with emission of a fast proton when struck by neutrons. In similar manner, radioactive isotopes of phosphorus, sulfur, calcium and other elements may be formed. The result of this sort of thing is that the effect of neutrons in tissue is greater than comparitive ionization figures, as measured in instruments, would indicate. Thus biologic effectiveness is rated at from two to ten times as great as that of gamma rays or even more, depending on the tissue concerned & the energy of the neutrons. The average ~~increase~~ for fast neutrons is usually placed as about a ~~five~~ ten times factor at the present time ~~and this figure appears likely to be revised upward~~.

PROTONS H^1 mass 1.0076 charge +1

These are identical with hydrogen nuclei and, although not of biologic importance in atomic bomb explosions, natural radioactive decay or pile operation, they are encountered in the course of scientific work and are produced secondarily in tissue by neutrons. They are potent ionizers by reason of mass and charge and will penetrate well if of high energy. In fact, it is hoped that they may someday have therapeutic applications since there is a marked gain in ionizing power as the speed of the particle lessens, in accordance with the Bragg effect described in the case of electrons. Some figures

are interesting here: Penetration to a depth of 10 cm. is possible with an energy of 115 mev. During the last centimeter of travel, ionization is six times that at the surface, and in the last half centimeter, 16 times that value.

It will be noted that the proton has a trifle less mass than the neutron. This correlates with the fact that 1 mev energy must be supplied to make possible the change of a proton to a neutron by emission of a positron and that neutrons by themselves are probably unstable.

DELTA RAYS

A number of secondary electrons produced by ionization have sufficient energy imparted to them to produce ionization themselves. Thus an electron ionization track will often show little offshoots where such has taken place. The subsidiary ionizing electrons which form these tracks, constitute the delta rays.

BREMSSTRAHLUNG RADIATION

When charged particles such as electrons near the end of their course in an absorption medium, irregularities occur and it can be noted that the absorption curve straggles owing to the final rapid deceleration or "braking" effect whereby the last energy is converted into soft gamma rays. These soft gamma rays are often spoken of as Bremsstrahlung.

Coming ~~now~~ to the medical and biological application of radioactive isotopes we find that such employment takes two main directions. First, there is the application to patients for therapeutic and occasionally diagnostic purposes. Then there is use in research, often ~~usually~~ by tracer methodology. In addition and as a sort of adjunct to radiation safety and practical applications, there are numerous studies involving the toxicity and metabolism of the isotopes themselves. Considering the first, it is natural to entertain the hope that perhaps an isotope may be found that will act as the magic weapon with which to conquer cancer completely, once and for all. Such, however, has not been found and it may well be that this complete measure of success will continue to elude us. There are several inherent difficulties. These are related to a sufficient degree of selective absorption of the particular elements concerned, convenient and effective types of radiation, suitable half life and relative freedom from toxic effects. We must also consider radiological hazards and precision in dosimetry. Administration of radioactive isotopes in a proper manner calls for much specialized knowledge, skill and training. Accordingly in the United States, hospitals or clinics desiring to obtain isotopes for clinical use, are required to have a supervisory committee composed of experts in internal medicine, hematology, radiation therapy and radiation physics.

Isotopes most frequently used in clinical practice are I^{131} P^{32} and Na^{24}. As is well known, certain thyroid tumors have a selective uptake of iodine and so are favorably affected by I^{131}.

Others do not, so that careful selection and preliminary studies with tracer amounts are requisite. Certain cases of hyperthyroidism and in particular those in which surgery is contraindicated or not acceptable, are also amenable to this form of therapy. Again in certain cases of coronary heart disease where lessened function of the thyroid is desired, I^{131} may be the method of choice in accomplishing this. P^{32}, as is well known, has beneficial effect on a number of neoplasms and has been used in cases of lymphomatous tumors, leukemias, polycythemia and occasionally by local application for skin lesions. A considerable generalized effect on all blood forming cells is a drawback in most instances, and, in many cases, conventional x-ray therapy answers equally well or better. Once more, careful selection of cases and appraisal of all circumstances are essential. Na^{24} is useful as a diagnostic tool in studying circulatory disorders. Finally, before leaving this aspect of isotope utilization, it should be noted that Co^{60} may eventually prove very useful as a substitute for radium. or more likely an adjunct.

These therapeutic and diagnostic uses are of course most interesting and often spectacular, but it is quite likely that the more slow and toilsome application of radioactive isotopes to biological research will yield the most benefit. The ability to trace important elements and the chemical molecules or radicals to which they are attached is naturally a great asset, and that is what the use of radioactive isotopes as tracers makes possible. All this is a subject for chapters, if not volumes, but it is appropriate to mention a few salient features here.

Methods of application include rate of appearance and disappearance of the radioactive elements along with quantitative radiation studies of tissue, tissue fluids and excretory products. In addition radioautography is extensively employed and it is often of great value to use radioactive tracers in partition chromatography.

Amongst the matters elucidated we can enumerate some that are very interesting and important. The concept that all body tissues are in a constant state of flux or "turnover" has been greatly amplified. The status of chemical bonds in organic compounds is being clarified and we find that certain bonds usually thought of as closed are in reality often open in the living cell. The transfer of water and solutes is becoming more accurately determined.

The constant recycling of CO_2 has been demonstrated and it is evident that CO_2 plays a more complex role than formerly believed. Radioiron is being used to study many problems involving erythrocytes and the metabolism of haemoglobin. Radiosodium is being used in study of peripheral vascular disease. Radiocarbon and phosphorus are being used in numerous biomedical studies. Radiogallium, which shows selective uptake in osteotenic lesions, is being used in study of bone tumors and may prove to have therapeutic application. Radioiodine is being used to tag diiodoflourescein to aid in the investigation of blood volume and also in localization of brain tumors.

Thus new pages in metabolism, diagnosis and therapy are being opened and we can expect that the next few decades in medicine will

be as brilliant and dazzling as those which brought us so many triumphs in the past.

All this sounds very hopeful and of course is; but this audience I am sure is interested in problems and shortcomings and so let us take a look.

General difficulties arise from the lack of isotopes with characteristics we would like. Oxygen, Nitrogen and Magnesium lack isotopes with useful half life. P_{32} although very useful, is a soft B emitter and so is often difficult to trace in vivo. C_{11} has such a short life that we can only use it right beside its place of origin. S35 is a soft B emitter too; likewise Fe55. C14 is not only a soft B emitter but lasts too long for comfort - over 6000 year half life.

There are also the matters of dosimety and radi~~ation~~ological safety. These are becoming better known and standardized. Certain commercial concerns can or will be able to supply well standardized preparations. This will be helpful, but special skills, techniques and consultations will continue to be requisite and radiologists should acquire at least a good general background in the problems involved so as to help meet them to the best interest of all concerned and retain supervision in an important field.

Radiological safety is very important not only to the patients and the supporting personnel but also the doctor concerned in administration. There is only one point I would make here, other than the routine one of studying carefully the particular ~~solution~~ situations involved in

a given installation. That point is: practice well and learn thoroughly the techniques involved (remote controls - special pipets, working by mirror images etc) so as to spare yourself ~~and in this instances~~ particularly your fingers and hands.

Among the problems related to isotopes an important and recurring one is the matter of decision whether or not to use a given isotope in a given case. We now have a virtual embarrassment of riches as to methods of attack against certain illnesses.

Thus in hyperthyroidism there is surgery, x-ray, I^{131}, and thiouracil. In leucemias we have often to decide between x-ray and P32. In Hodgkin's disease there is also nitrogen mustard. What it boils down to is careful study of cases, consultation and preferably presentation before tumor boards or clinical conferences for discussion and in final decision.

The ~~final~~ best answers are not yet at hand to permit of much dogmatization ~~on all aspects~~ and a brief general summary such as this can hardly go beyond a few general observations as to factors we should take into account; and among these we should consider not only what seems theoretically best but what modality the staff concerned has the most ~~inference~~ experience with and greatest skill.

The advisability of surgery in hyperthyroidism is of course always traditionally related to the age and condition of the patient. In this regard it can be pointed out that there is now less call than ever for taking chances on poor or dubious risks. X-ray versus iodine is still another problem. Both can control hyperthyroidism. X-ray involves a series of exposures and may entail irritation of the larynx, trachea and oesophagus. However, careful technique can

avoid or minimize this. Iodine 131 is relatively easy on the patient but involves a lot of careful work by a skilled staff. It also involves some generalized exposure of the patient. This may be undesirable in reproductive years and particularly in certain phases.

Thyroid carcinomas, of course, involve careful evaluation of the iodine uptake to determine whether an response is possible; and it is interesting to note that there is now evidence to suggest that promptly frozen biopsy material may prove suitable for preliminary study of this factor. (Am. J. Clin. Path., Sept 1951, W. N. Harsha & B. R. Harsha).

This may permit of more widespread use of radioiodine in the future.

In leucemias as already noted P32 has been found very useful. Nevertheless, in most cases of myelogenous leucemias and chronic lymphatic leucemias it is often possible to maintain long periods of palliation, ability to carry on routine affairs of life, easy and simply by x-ray.

I would note too that very small doses to the splenic area will usually suffice in ~~many~~ these cases and that with such small doses the complaints of radiation illness are seldom of serious concern.

Hodgkin's disease presents ~~such~~ a highly varied pictures as related to rapidity of progress, degree of localization or, on the other hand, spread, presence or not of bone lesions etc. ~~that~~ Thus we have here a classic instance for nice judgment in each individual case. My own experience leans to x-ray but there are certainly cases for P32 and consideration of nitrogen mustard

Polycythemia vera in the past called for very strenuous dosage by x-ray and it appears now that treatment by P32 is easier on the patient ~~thus x-ray is~~ and in general preferable to x ray.

Multiple ~~myeloinas~~ myeloma also offers possibilities to isotope therapy and it is certain that our armamment of helpful isotopes is going to increase, not forgetting useful application of B emitters to skin lesions. These should be particularly helpful in hemangiomas near growth centers.

Related to ~~these~~ the particulate radiations of isotopes we have some new possibilities from apparatus. It is now possible to pull the electron beam from a betatron or synchotron and we will also be able to obtain beams of high energy protons ~~also~~. Thus We may be able to do some effective therapy with these rays because of the Bragg effect, as already noted.

This brings to mind the vexed matter of supervoltage in therapy. Many technical problems are involved and I would only leave as the point to be remembered that the key to all ~~radioactive~~ radiation effects lies in the matter of absorption. Where the maximum energy is absorbed and that of where the emission effect will be. In other words we have & more scientifically to consider: At what depth and in what tissue is the maximum density of ionization occurring? Thatis what we must always think of in relation both to tumors we may wish to destroy, normal tissues we may wish to spare and and ~~both~~ pathological conditions ~~are~~ we ~~very weak~~ may wish to effect. Differences in voltage, filtration, distant factors are all related to ~~that~~ (the penetration) factor, ~~rather than~~ (and not to any qualitative difference in effects ~~believed~~ of "soft" and "hard" rays. Discuss pair formation

At this point it is high time to desist and in closing I would like to encourage all of us in radiology, and including myself,

to take more time to keep abreast of our responsibilities in the matter of isotopes. They are very much here to stay and our help is needed on behalf of our patients and colleagues. We need also to render that help as a matter of enlightened self interest as promoting more intimate clinical contacts with patients and staff (~~something~~, which we readily tend to lose in our specialty) and increasing our professional scope, ability ~~and~~ usefulness, and prestige. If we should lose cont~~act~~rol ~~our~~ or at least supervision of the field by default everyone will be the poorer thereby.

NOTES ON ATOMIC MEDICINE

STAFF MANHATTAN GENERAL HOSPITAL
New York, New York

19 December 1951

SALVATION ARMY

New York, New York

31 January 1952

SALVATION ARMY
New York

R.W. AND FOOD ANIMALS

PREPARED FOR PROJECT EAST RIVER

6 February 1952

R.W. & FOOD ANIMALS
Project East River

6 Feb

R.W. AND FOOD ANIMALS */ 1st DRAFT
C.F. BEHRENS

Unfinished for PERC
Not cleared for general use

The use of R.W. is in more dubious status than other special weapons. Sensational literature has pictured it a fantastically potent role and on the other hand formal reports from the Department of Defense point up difficulties. The former gives an impression that with remarkable ease a city can be made uninhabitable in prepetuity. The latter indicates that it is not so. It is pointed out in the more sober reports that desirable agents must compete for production with essential fissionable material or be extracted with some difficulties from waste fission products from reactors; that the fission products from a nuclear reactor are a mixture of elements many of which do not have profitable radiation characteristics or are short lived. In general the elements we wish to use must be constantly replenished and involve difficulties in suitable delivery and distribution. Limitations are pointed up by the Navy's experience at Bikini where access to heavily contaminated ships was made relatively early.

*/ Not cleared for publication. Unclassified material extracted from CEBAR.

Nevertheless it must be conceded that R W. can prove an important harassing factor. It can interrupt production, deny profitable access to important areas and conduce to panic and disintegration of morale. It could also necessitate expensive and time consuming decontamination.

Direct and immediate effects of R.W. as an anti-personnel agent are not important. Still less would direct effects on live stock be a matter of serious consideration in comparison with effects on humans. In fact it would not appear at all likely at first glance, that R.W. would be employed against our food animals. Nevertheless the matter can not be summarily dismissed.

An attack by R.W. agents that would contaminate large numbers of animals in stock yards and the stock yards themselves would be very embarrassing and troublesome and might tempt an enemy. It would pose difficult problems as to the care and disposition of the animals affected and might occasion serious losses. In meeting such a situation, precise local details would vary

and call for various specific measures, which could hardly be specified in detail here. It is better to indicate general operating principles from which details of action can be derived in accordance with accepted levels of radioactivity related to human safety.

First it can be said that probable levels of radioactivity would not produce rapidly lethal effects i.e. death within 24-28 hours. This statement might conceivably be subject to modifications in a closely related type of attack. What is referred to here is not R.W. as such but incidental radiological exposure from an A bomb attack especially in the form of an underwater burst. The deluge of radioactive water might affect huge numbers of animals in certain localities. An underwater burst is not apt to be considered a profitable military investment in most places but might be attempted wherever extensive bodies of water are convenient.

In general and as already mentioned the levels of exposure in R.W. are not at all likely to be high. Nor would the animals thus exposed be necessarily rendered unfit for human consumption because

of radiation effects. However, special problems would be involved concerning:

Monitoring,
Safety standards both for use of the animals and those processing them,
Decontamination possibilities,
Metabolic considerations.

The agents likely to be used are subject to conjecture and might be in any one of three general categories: (a) crude fission products from a nuclear reactor, (b) elements extracted from fission products, (c) elements purposely made for the purpose.

Crude fission products would involve a variety of B γ emitters. The latter two categories would be more apt to comprise energetic γ emitters.

Early decontamination would be important and helpful even if not completely effective. Simple hosing down and use of dip methods would carry off excessive and dangerous amounts and make possible slaughtering either at once or after a delay to permit further lessening of radioactivity. There is no precise data on this but it appears a reasonable expectation.

In the event of exceedingly heavy exposures such as might be anticipated from nuclear bombs, early slaughter might be considered in some instances. It should anticipate serious radiation illness and accordingly take place within a week to ten days. Monitoring data would indicate the basis for such consideration and the degree of special protection or care requisite for slaughter house employees. It would also indicate practicability by giving a measure of the expense and trouble and danger involved versus the value of the meat products.

However, since the animals must be killed and handled in any case it would seem that it would involve little more hazard to hose them down or dip then kill them and promptly freeze the carcasses. Refrigerators set aside for heavey contaminated carcasses could be allowed to retain them until radiation has subsided to the point where hides can be removed etc. with safety.

As a fundamental principle we should not resort to prompt destruction and burial of all contaminated animals. Such an outcome might readily transpire under conditions of stress, excitement and

hasty judgment, and is not at all necessary. There should be careful evaluation of the situation.

The question naturally comes up here as to whether the meat of contaminated animals would be safe to eat. The answer is in the affirmative with some qualifications which will be mentioned later. This favorable answer is implicit in the nature of the contaminating agents and the metabolic factors involved.

A great deal of work has been done on the subject of the metabolism of radioactive isotopes and is best summarized in tables. The table prepared by J. G. Hamilton is pertinent here.

SUMMARY OF THE METABOLISM OF THE PRINCIPAL MEMBERS OF THE LONG-LIVED FISSION PRODUCTS AND PLUTONIUM IN THE RAT AFTER PARENTERAL AND ORAL ADMINISTRATION

Radioelement	Half Life	Fission Yield (%)	Oral Absorption (%)	Accumulation Principal Organ of Retention (%)	Rate of Elimination From Principal Organs of Retention
Strontium					
Sr^{89}	53.0 days	4.6	5-60	70 (bone)	>200 days (bone)
Sr^{90}	25.0 yr.				
Barium					
Ba^{140}	12.8 days	6.1	5-60	60 (bone)	>50 days (bone)
Iodine					
I^{131}	8.0 days	2.8	100	20 (thyroid gland≠)	30 days (thyroid gland≠)
Cesium					
Cs^{135}	33.0 yr.	---	100	45 (muscle)	15 days (muscle)

Radioelement	Half Life	Fission Yield (%)	Oral Absorption (%)	Accumulation Principal Organ of Retention (%)	Rate of Elimination From Principal Organ of Retention
Yttrium					
Y^{91}	57.0 days	5.9	<0.05	65 (bone)	>500 days (bone)
				70 (liver)	10 days (liver)
Lanthanum					
La^{140}	40.0 hr.	6.1	<0.05	30 (bone)	25 days (bone)
Cerium					
Ce^{141}	28.0 days	5.7	<0.05	50 (liver)	10 days (liver)
Ce^{144}	275.0 days	5.3	0.05	25 (bone)	100 days (bone)
				35 (liver)	10 days (liver)
Praseodymium					
Pr^{143}	13.8 days	5.4	0.5	50 (bone)	>100 days (bone)
Element 61				55 (liver)	10 days (liver)
61^{147}	3.7 yr.	2.6	<0.05	35 (bone)	100 days (bone)
Zirconium					
Zr^{95}	65.0 days	6.4	<0.05	35 (bone)	>100 days (bone)
				30 (bone)	30 days (bone)
Columbium					
Cb^{95}	37.0 days	6.4	<0.5	25 (blood)	1 day (blood)
Ruthenium					
Ru^{103}	42.0 days	3.7			
Ru^{106}	1.0 yr.	0.5	0.05	3.5 (kidneys)	20 days (kidneys)
Tellurium					
Te^{127}	90.0 days	0.033	25.0	15 (blood)	15 days (blood)
Te^{129}	32.0 days	0.19	25.0	6 (kidneys)	15 days (kidneys)
Xenon					
Xe^{133}	5.3 days	4.5	Distribution proportional to fat content of body; half time in body, 2 hr.		
Plutonium					
Pu^{239}	2.2×10^4yr	...	0.007	75 (bone)	2 yr (bone)

Another table prepared by Behrens in Atomic Medicine may also be

helpful:

TABLE OF METABOLIC FEATURES OF IMPORTANT RADIOACTIVE ISOTOPES

Element		A	Radiation	Absorption	Localization	Elimination
14.8 hrs	Na	24	Beta, gamma	complete	general	rapid
14.3 days	P	32	Beta	excellent	bone and some general	few weeks
180 days	Ca	45	Beta, gamma	moderate	bone	slow
55 days	Sr	89	Beta	excellent	bone	slow
25 yrs	Sr	90	Beta	excellent	bone	very slow
57 days	Y	91	Beta	poor	bone	very slow
65 days	Yr	93	Beta, gamma	poor	bone	slow
55 days	Cb*	93	Beta, gamma	slight	bone	slow
42 days	Ru	103	Beta, gamma	poor	kidney	few weeks
1 yr	Ru	106	Beta	poor	kidney	few weeks
90 days	Te	127	Gamma (soft)	moderate	kidney	few weeks
32 days	Te	129	Gamma (soft)	moderate	kidney	few weeks
8 days	I	131	Beta, gamma	complete	thyroid	month
2 yrs.	Cs	134	Beta, gamma	complete	muscle and general	fairly rapid
33 yrs.	Cs	137	Beta, gamma	complete	muscle and general	fairly rapid
12.8 days	Ba	140	Beta, gamma	good	bone	very slow
40 hrs	La	140	Beta, gamma	poor	bone and liver	few weeks
140 days	Ce	140	Gamma (soft)	poor	bone and liver	slow
28 days	Ce	141	Beta, gamma	poor	bone and liver	slow
300 days	Ce	144	Beta	poor	bone and liver	slow
13.5 days	Pr	143	Beta	slight	bone and liver	slow
3.7 yr.	Ill	147	Beta	poor	bone and liver	slow
140 days	Po	210	Alpha, gamma	good	kidneys	slow
1590 yrs.	Ra	226	Alpha, gamma	good	bone	virtually permanent
4.5×10^9	Ur	238	Alpha	poor	lungs and kidneys	slow
24×10^4	Pu	239	Alpha	very poor	lungs and bone	virtually permanent

NOTES:
(1) Poorly absorbed isotopes may damage the gastro-intestinal tract during passage if in sufficient concentration.
(2) Poorly absorbed isotopes tend to be retained in the lung, if and when they gain access.
(3) Retention in bones is usually a matter of months, approaching a year or more in the case of Sr and becoming virtually permanent in the case of Ra and Pu.
(4) Liver retention is about 10 days in experimental animals and kidney retention about 20 days.

* Cb now Nb (Niobium) There is also a 35 day Nb (Bγ) derived from 65 d Zr (Bγ).

It will be seen from this that the long lived isotopes are mainly bone seekers except that there is also predilection for the liver and kidneys in some instances; also the thyroid for iodine. The main point is that the muscles, which are of principle importance from a food standpoint do not harbor the radioactive materials long. The isotope which favors muscle is Cesium and it turns out that the element is quickly disposed of.

The conclusion to be drawn is that the meat products we are chiefly concerned with would be safe in any event. The liver, kidneys and thyroid would be suspect but could be made the object of delay under refrigeration and monitoring. In general it would be possible in any event to store meat in cold storage for considerable periods to diminish radiation.

The hides, of course, would tend to retain more or less contamination. These too could be stored to let time get in its work and be subjected to monitoring and if appropriate decontamination.

The bones of animals are, of course, an important consideration and such long lived isotopes as Sr^{90} linger a long while. However,

human consumption is not involved and the main factor would be safety of the people employed in processing them. It is doubtful that dangerous or unacceptable radiation levels would result from use in making fertilizer and bone meal products.

One problem might be mentioned here that is only indirectly related to R.W. (in that ionizing radiation is involved). It is quite conceivable in a conventional air burst we may have many animals who have been subjected to serious and perhaps lethal amounts of radiation. Such animals are due to fall ill and perhaps die chiefly in the second and third weeks. No significant contamination is likely to be involved but the question will come up as to whether or not products from such animals are fit to use. Here the answer is definitely in the affirmative provided the animals are slaughtered before they become seriously ill. Once serious radiation illness develops there will be poor nutrition, hemorrhage and severe infections. These would occasion rejection.

This gives much of the general background. It serves to indicate that we do have a problem here, worth careful thought. It could well be that in an economy of abundance, many people will react by saying "why bother". However, serious numbers of animals may be involved and meat is no longer superabundant. It is precious and in addition many by-products can ill be spared. There economic, nutritional and medical aspects are involved.

As already noted much research has been done on the metabolism of radioactive isotopes but in spite of this body of information we find in these discussions that we are dealing with possibilities concerning which direct experience is lacking.

It therefore becomes a proper matter to suggest serious thought to making tests on experimental animals in which probable conditions resulting from R.W. attack are reproduced. Studies could then be made of the practical radiological safety problems involved in the utilization of contaminated animals for food. These problems relate largely to the safety of the stock yard and slaughter house workers.

SUMMARY AND CONCLUSION

1. R.W. has important possibilities related to the animal industry through possible involvement of large numbers of animals in the stock yards.

2. Levels of contamination and exposure might reach substantial levels but would not be rapidly lethal and seldom lethal at all except very remotely.

3. Contamination and exposure could be considerably reduced by hosing down or dipping procedures and use of the time factor.

4. It should not be assumed that contaminated or exposed animals are unfit for human consumption and destroyed without careful review of circumstances and monitoring data.

5. Meat in nearly all instances would be safe to use. Holding in cold storage can be employed whenever necessary or advisable. This would probably apply only to glandular organs, particularly kidneys, liver and thyroid but could be extended to whole carcasses.

6. Practical problems would largely involve radiological safety factors related to handling and slaughtering animals and effecting some measure of decontamination and preventing any mechanical contamination of meat. From the standpoint of safety of workers, it would be possible to let animals "cool off" before slaughtering when it is unlikely that animals are likely to fall ill.

7. Heavy contamination of promptly lethal magnitude would be unlikely from R.W. but might result from an underwater burst of an atomic bomb. Problems would be more severe but careful monitoring and consideration of circumstances might indicate possibility of utilizing exposed animals in many instances.

8. Early slaughter of animals heavily exposed to initial nuclear radiation (γ and neutrons) from an air burst is admisable. Contamination problems would not be present in this case.

9. Research on practical problems of handling contaminated food animals is suggested.

Before closing it might be noted that pets and stray animals may prove a minor problem if contaminated.

Provision for monitoring, rounding up strays, segregation and decontamination is advisable.

Hasty decision to destroy all contaminated pets should be avoided. Most can be saved and unclaimed strays would be very valuable from the standpoint of radiobiological study. They should be made available to experts in that field. The results of such study would aid greatly in estimating the liability to radiological injury of people exposed.

It should be noted in this regard that in many localities there are legal obstacles to such action. Animal pounds are required to destroy unclaimed strays after a given period and are often forbidden to make them available for medical purposes.

CASUALTY ESTIMATES
Project East River

CASUALTY ESTIMATES

PREPARED FOR PROJECT EAST RIVER

March, 1952

~~RESTRICTED~~
~~SECURITY INFORMATION~~

PREPARED FOR P.E.R., March 1952
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Publication

CASUALTY ESTIMATES

Many elaborate tabulations have been made and are readily avaiable in government publications and also books and articles. In general they are derived or (to borrow the popular term of the physicists) extrapolated from the records of Hiroshima and Nagasaki in Japan and from the saturation bombings of Tokyo, Berlin and Hamburg. They are also based on probable zones of destruction and by using overlays marked with % we can calculate probable casualties.

The current Civil Defense brochure gives detailed tables. Admiral Greaves in his chapter on hospital and public health problems in "After the A Bomb" elaborates further on the matter and provides a set of tables.

All these, of course, involve uncertainties and it is well to review in some detail the factors which make for uncertainty and see what we can do to evaluate them properly.

~~RESTRICTED~~

WARNING

The matter of warning is given a very high evaluation. With a normal (20 KT) bomb, Admiral Greaves estimated effects on casualties as follows with, however, the proviso that we should beware of optimism in estimating our needs.

ESTIMATED VALUE OF WARNING */

Distance	Deaths	Surviving Casualties	Uninjured
0-½ mile	81 to 67.5	19 to 22.5	0 to 10%
½ mile	45 to 27	40 to 23	15 to 50
1 - 1½ miles	15 to 5%	40 to 25	45 to 70
1½ - 2 miles	2 to 1%	18 to 9	80 to 90
2 - 2½ miles	0	10 to 5	90 to 95
2½ - 3 miles	0	5 to 1	95 to 99
3 - 3½ miles	0	1 to 0	99 to 100

*/ Based on Table 1, Page 22, "After the A Bomb"

Figures such as these have to be taken as indicated by the author without too much optimism. Yet the nature of casualties from atomic weapons is such as to suggest a high value for sufficient warning time.

Naturally in the zone of virtually complete destruction people tend to be killed many times over by lethal amounts of

Direct heat and also flash
Ionizing radiation (γ and neutrons)
Crushing injuries

Within a radius of half a mile - (3000-3600 ft) there are serious and lethal effects from flash and from ionizing radiation (γ) so that people exposed in the open have little chance of survival. When you consider that up to 60% of the casualties will be from flash burns and another 15-20% from ionizing radiation, it becomes evident that the ability to get into some type of shelter will prevent many casualties even granting that the casualties from crushing trauma and flying missiles of one description or another will take a heavy toll. Also that some of the people we have saved from burns may well fall victims to radiation illness.

Admiral Greaves figures that with a normal bomb and assuming a population of 120,000 within 5 miles of ground zero

that warning should reduce deaths from 21,400 to 15,075 (17.8 to 12.5%); injured from 20,800 to 12,825 (17.3 to 10.7%)

A lengthy warning such as would permit of depopulating congested areas would obviously reduce casualties well beyond those tabulated. Accordingly, warning becomes a most important element, and one worth expenditure of much time, effort and money.

Number of Bombs. A surprise attack on a small scale would bring heavy reprisals on an enemy just as surely as a heavy attack and it follows that we must expect an enemy, if he is going to attack at all, to do his best to overwhelm us and saturate our defenses with his first blow.

It is well known that we have a considerable stock pile of A bombs - which spell ability to retaliate heavily. Thus an attack on us would be predicated on ability to hit us extremely hard. That means that the effort would certainly be made, to hit our large targets with a number of bombs and very likely

combine Chemical Warfare and perhaps Biological and Radiological Warfare as well.

Radiological Warfare might not be conducted as such but incidental to a drop into an adjacent body of water or covert planting of a bomb by a merchant ship. A subsurface burst would entail a huge radiation hazard involving vital shipping areas.

At all events we might expect a number of bombs combined with other weapons something as follows: 1 A bomb for each 5 - 10 square miles plus one or more subsurface harbor bursts; Chemical Warfare with nerve gases and possibly mustard; Biological Warfare by sabotage.

Power of Bombs. Without resort to the entirely speculative and problematical use of the thermo nuclear type of reaction involving the combination of lighter elements to form Helium, it is possible to raise the power of fission bombs to 100 or more K.T. equivalent.

The decision, which to use, will probably be related to the number of bombing planes an enemy thinks he can put over the targets. Ordinarily a number of smaller bombs can cause more damage than a single large one.

Scaling laws give us the following:

Blast - Proportional to cube root (8 x to double effect)
Thermal - Direct proportion (double will double)
Ionizing Radiation - Roughly proportional
Area and over all damage and casualties - Proportional to 2/3 power of energy release

Doubling energy will increase general effect by 60%. However, the range effect is less.

Figuring on a 100 K.T. bomb, range for thermal and blast effects is only increased 70% and ionizing radiation 30% - this for a 5X increase in energy. Naturally, however, within the range of effective action damage and casualties will be more severe.

In general it would appear that an approximation to the nominal 20 K.T. level of energy is quite likely and as regards

figures it is probable that the present estimates on conventional air bursts are fairly realistic.

Manner of Employment. Air bursts at an elevation of approximately 2000 ft are most destructive and it is assumed that this will be the favored mode of attack. Nevertheless a subsurface harbor burst could impede shipping and navigation and might tempt an enemy on that score.

Subsurface bursts would greatly decrease blast and thermal effects but produce more radiation casualties. After on hour, Bikini measurements indicate 400 r/hr over a radius of slightly more than half a mile (approximately 3000 ft) as the likely surface contamination; 50 "r" at 2 miles and 10 r at 3½ miles. Thus one could readily walk to safety over such an area without receiving dangerous amount.

Contamination by the base surge and fall out, in such cases would produce total dosage of 8000 r over a radius of

3/4 miles, 1000 r over about 1 3/4 miles, 400 r over $2\frac{1}{4}$ miles and 100 r over $3\frac{1}{2}$ miles (all downwind). */ Half of the exposure would be received in less than 30 minutes. **/ Accordingly, people within a 2 mile radius downwind and subject to gross contamination would have little chance to survive unless they received almost immediate decontamination. From about 2 miles out downwind they would receive amounts ranging downwind from about 400 r in a half hour. This gives an idea of how prompt decontamination would have to be in order to prevent dangerous or lethal exposure. Fortunately, plain showers will take the bulk of radiation off. The important thing is that those drenched should not be regarded as beyond hope. Quick access (and it must be quick) to showers will save most lives. Another important factor will be protection afforded by clothing - particularly, of course, water proof clothing. The radioactive fission products are $B^- \gamma$ emitters which means that the B radiation

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*/ See Figs 8.91 abc page 281, Effects of Atomic Weapons
**/ See page 279, par 8.91 Effects of Atomic Weapons which gives about 90% within 30 minutes.

will be largely screened out by the clothing. However, all contaminated clothing must be discarded promptly.

Since the prospect of subsurface harbor bursts produced either by drops or else the covert activity of enemy merchant ships is not all unrealistic, it is proper to consider decontamination facilities and clothing supplies a very real element in Civil Defense.

The value of even a short delay in emerging from shelter or entering the contaminated area is pointed up in the reduction to less than half in 30 minutes. There is actually a factor of 400 to 1 in the interval between 1 and 4 minutes (par 8.93, page 281, Effects of Atomic Weapons).

The casualties to be expected from such a contaminated area will be predominately radiologic and will depend to a very large extent on the number of people within the 2 mile radius (downwind at 5 knots) caught in the open, or in habitatious where breakage of glass and damage to buildings permit of gross contamination. Exact estimate is very difficult but if we

consider about 10,000 people per square mile we come up with about 5 square miles where immediate danger from intense radioactivity is to be reckoned with as endangering 50,000 people. Of these a good many would be protected from gross contamination but it would not be amiss to count on at least 10,000 to 15,000 cases of gross dangerous contamination who would require prompt decontamination and close observation. A large proportion, at least half, would be candidates for serious radiation illness. Warning and advance preparation would pay large dividends here.

State of Weather. Heavy weather, rain, fog, mist and snow would greatly diminish flash casualties, and slightly reduce shock from blast. Fall out might be increased although it is not expected that this would prove more than a nuisance factor, i.e., it would not be in the casualty producing range.

Time of Day. The day time brings maximum population to urban areas and the greatest havoc among workers would result

from exploiting the hours for changing shifts. However, it is not likely that an enemy can pin the time down too precisely in view of the thousands of miles to traverse on the bombing raid. Night time and dirty weather may be utilized to provide the best opportunity for most planes to get through.

Types of Building. Enormous differences are involved here and involve detailed analysis in the individual cities. Many ordinary brick structures will prove nothing but traps and once more the importance of warning and opportunity to seek substantial structures becomes obviously important. The effect on casualty reduction resulting from better type of structure, is really included in the "warning time reduction" since the warning enables people to disperse or find better shelter.

Organization of Civil Defense. The organization of a proper Civil Defense is what can be expected to make huge difference between Japanese losses and any we may have to incur.

This is the subject of the whole general consideration and it is only pertinent to state here that obviously, good results in preventing and caring for casualties can only flow from -

Adequate plans
Good organization with well and properly defined lines of authority
Good logistics
Well trained damage control and rescue squads
Virtually universal first aid instructions

Special provision for the mass care of all types of casualties is of extreme importance; shock teams, surgical teams, burn teams, radiation teams, streamlined and economical methods - should all be planned for, organized and trained in advance.

In the midst of all these variables we are faced with the need of some sort of estimate for cities to plan by realistically.

The preceding gives some notion but perhaps it can be pinned down further as related to total population.

As a starting point for minimum preparation we might see how we come out in the matter of casualties, as related to total population and assuming advance warning.

The tabulation that follows is calculated from Admiral Greaves' percentages for casualties when there is advance warning and based on a Population Density of 15,000 per square mile with warning.

Radius Zone Miles	Area Zone Sq. Miles	Population	%	Killed Number	%	Injured Number	%	Uninjured Number
0.5	0.25	3,750	67.5	2,531	22.5	844	10	375
0.5-1	2.89	43,350	27	11,705	23	9,970	50	21,675
1.0-1.5	3.93	58,950	5	2,947	25	14,738	70	41,265
1.5-2.0	5.50	82,500	1	825	9	7,425	90	74,250
2.0-2.5	7.07	106,050	0	0	5	5,303	95	100,747
2.5-3	8.63	129,450	0	0	1	1,295	99	128,155
3 +	-	-	0	0	0	0	100	
TOTAL (for 3 mile radius)	28.27	424,050	4.25%	18,008	9.33	29,575	86.41	366,467

The tabulation when worked out as above gives us 18,008 killed and 39,575 injured making a total of 57,583 for a population of 424,050 contained in a zone of 3 miles radius.

This is based on a population density of 15,000 per square mile. A tabulation of cities is as follows. (From Atomic Disaster Planning by O. Schneider and E. R. King in "Atomic Medicine", page 212, as of 1939-40.)

Population Densities
United States and
Japanese Cities

City	Population	Area Sq. Mile	Population Density per Sq. Mile
New York	7,492,000	322.8	23,200
Manhattan (day)	3,200,000	22.2	145,000
Manhattan (night)	1,689,000	22.2	76,000
Bronx	1,493,700	41.4	34,000
Brooklyn	2,792,600	80.9	34,200
Queens	1,340,500	121.1	11,000
Staten Island	176,200	57.2	3,000
Washington	663,091	61.4	11,000
Chicago	3,396,808	206.7	16,500
Detroit	1,623,452	137.9	11,750
San Francisco	634,536	44.6	14,250
Hiroshima	340,000 (1)	26.5	12,750
Center of City	140,000 (2)	4.0	35,000
Nagasaki	250,000 (1)	35.0	7,000
Built-up Area	220,000 (2)	3.4	65,000

(1) Prewar
(2) As of 1 Aug 1945

It will be seen from this that there is marked variation in cities and in different portions of the same cities. Nevertheless it would appear that assuming a warning, we should plan on a minimum of 15% of a given population being casualties of which 10% will need hospitalization and 5% will be dead.

It would be plausible to assume that an enemy would not space bombs farther apart than 6 miles if he wants to knock out a city. He might place them closer, of course, causing an overlap but reducing the overall area. The effect of this, however, would be to increase casualties. However, a city well covered on a 3 mile radius basis would experience great difficulties or delay in becoming functional again.

At all events it would seem that a figure 10% of the total population for injured personnel would seem an absolute minimum and probably too conservative.

In view of possibility of "no warning" and other complications it might be well to double this. Then we would have to provide for casualties amounting to 20% of the population of a given target area.

MEDICAL CONCERNS ESF

(Part of Briefing for Pattes Rel. Officer) Bases for presentation ESF on Jan 1952

MEDICAL CONCERNS EASTERN SEA FRONTIER

The importance of the Eastern Sea Frontier in present day naval operations has been emphatically emphasized and clarified by Admiral Badger and other members of the Staff. The medical concerns naturally reflect the general importance and functioning of the Eastern Sea Frontier into medical channels. Medical matters are a vital element in logistics planning and it follows that the Commander and his staff should have readily available a medical officer.

Aside from planning there may at any time, due to war and other emergency, be need for aid or intervention to prevent or remedy overloading of any particular units and make certain that patients are being accommodated efficiently and safely; also without waste of manpower, money or material. As we shall see economy of means is of extreme importance in the medical field today.

The matter of support and supply present in general huge problems. So heavy are the efforts required that at times it would seem that the tail is wagging the dog. This is an assumption very readily made applicable to medicine, because medical matters do not tend to seem important when we are not sick or injured.

It is axiomatic that the major basic concern of all of us in uniform is combat and all that conduces to victory. It would seem a great boon if, as in primitive times, all had to snatch up weapons and turn to in the fray. It's been a long long time sinch things were that simple; even the ancient Romans had to deal with extensive

equipment or impedimenta; and we find that our fighting men and fighting ships can't function without elaborate and intricate supporting elements. Even in the days of wooden ships and iron men the matter of logistics was a prime headache. And if you dip into the famous diary of Samuel Pepys and with an eye for something else besides his amusing indiscretions, you will find much to interest the Navy man. He was Secretary of the Navy and a good one to King Charles II and in his account you will find quite a few references to his troubles in equipping and maintaining the fleet and also defending the navy in parliament.

We can note that in the early days surgery was crude indeed and the medical provisions required not at all extensive. On the other hand death and disease were extensive. In our times in our Navy and Army, provision is elaborate and costly in terms of materiel and personnel, but it is well worth this cost. It has brought about a great transition from the days even of our Civil War when 300,000 union soldiers died of disease as compared to 95,000 in combat. In World War II death from combat topped those from disease for the first time. Of the wounded reaching hospitals, 8.3% died in World War I and 4.5 in World War II. In Korea the rate is about half of that.

The value of this is quite apparent in terms of humanitarian considerations. Value is also there in military terms and is all the more important to us, in that our people represent such heavy investments in training. We make skill, initiative, fire power and better

weapons pay off against mass tactics. We cannot, in the face of the huge manpower of our adversaries neglect anything that will conserve our manpower. By prompt effective treatment we aim to return as many men to combat and avoid evacuation and when evacuation is necessary arrange efficient transportation.

Then in actual operations two main considerations prevail. Advancing life saving treatment right up to the front and evacuating serious casualties at the earliest possible moment. A third might well be added, which although sometimes regarded as a side show, may make the difference between success and failure of a campaign. I refer to our epidemiological units which are designed to deal with whatever infection problems are present. A lot of fascinating and also distressing medical history can be found on the score of epidemic diseases in war and so there can be no doubt but that serious efforts at prevention play a role of extreme importance. The sinister possibilities of BW also point up the need for units trained and equipped to deal with infectious disease.

The full measure of medical support is not easy to provide. Medical care costs money, requires personnel, takes up transport space and involves troublesome handicaps to a Commander heavily burdened with the immediate problems of battles and campaign. Thus utmost economy is needed on that score. We need to do everything possible at the minimum of logistic cost and of course are always under pressure to do just that - which is inevitable and as it should be. This isn't all, however. Nurses, doctors and dentists and

hospitals are well below the numerical levels desired, throughout the country in general and no rapid improvement is possible. Thus when the services mobilize, the country feels the pinch and the reserve or civilian doctors dragged away from their practices, view their duties and assignments with gimlet eyes and critical disposition. The medical associations take a hand too at the same time.

War is a wasteful thing. When expansion on a gigantic scale becomes imperative and one can't crystal ball the intentions of an enemy or the duration and outcome of campaign, there will be many rough spots, painful and unavoidable necessities, and some disatisfaction much of which flares up when the war crisis is past.

At any rate, following the war, we were just about investigated to death and I mean that literally because if some people had their way our service medical departments as we know them would have been things of the past.

All this points up the need for good management and economy, and also being ready to defend our service medical departments lest hostile criticism result in drastic changes reminiscent of the old proverb about throwing out the baby with the dirty water. A point often coming up for argument is the large number of doctors required by the services. There are many reasons why the services and in particular the Navy needs a much larger ratio of doctors than the civilian population but many people are prone to yell "bloody murder" when they see the figures and do not bother to look further. They note a rough average of 1 doctor to 1000 civilians and 4 to 6 per

thousand for the services and that is enough to cause an explosion of wrath. I won't burden you with a full account of whys and wherefores but will mention that our "thousand" is first of all a misnomer and a gross one. That 1000 represents military strength and not the total people cared for. We have a vast army of civil service personnel who must be given physical exams and are entitled to "on the job" medical care. Our 1000 service people also have dependents who receive care. There are retired people to care for. We take a number of V.A. patients in some of our hospitals and so it goes. Again small ships and stations when remote or isolated can't be provided for by fractionated doctors, dentists and nurses. This naturally "ups" our ratio. There are also matters of training, research and administration to provide for. Dr. Rusk of the President's Medical Manpower Committee recommends 3.7/1000 ratio. Our plans call for five. With considerable economy we can probably do fairly well with four.

To proceed then, we find that civilian pressure as well as our own logistic welfare calls on us for striking the best and most economical balance possible in providing medical support. We can well make an addition to the familiar slogan or motto of the medical department vainly to keep our people at the guns; we can add with least possible cost in manpower and material. As Admiral Badger pointed out, that is a major responsibility in all our planning.

Much study and thought has gone into the matter and it brings up one of the most ancient of human problems that of a good flexible organization which strikes a balance between centralized and local operations. It is easy to let things slide and it is also easy to

become too rigid and ponderous so that we advance by fractions of an inch in millimeter strides and find most documents have aged in the wood as they are routed via numerous desks. Back in the last century our British cousins must have had a dash of that trouble, for that able and interesting novelist Charles Dickens wrote a satirical account of what he called the "Circumlocution Office" which he described as one of the main features of government in London.

Not only governments are affected by ponderous and unresponsive overgrowth, but commercial companies as well, as many of us know from personal experience and it is interesting to note that one of our largest commercial enterprises - one which takes in the whole country, found itself at a disadvantage in competition with smaller competitors. It was too slow and inflexible in action. It met the situation by division, not like all Gaul, into three parts, but into seven, each of them practically autonomous in local functioning but integrated financially and policy-wide.

The Navy, of course, has traditionally operated through independent naval districts, responsible to the Navy Department with its various bureaus. Thus local flexibility has been retained in large measure, but integration of the work of districts, calls for added consideration. Thus we have the Sea Frontiers. These as of course you know, are required to effect this integration of the work of the districts, since tasks in support of the fleet and overseas operations often transcent the scope and power of any single district to accomplish or bureau to regulate.

In medical matters of the Frontier it is necessary to note some differences from the general functional picture. In the efforts to insure economies considerable regulating power over all the services has been taken over by the Department of Defense. Here a Medical Council has been set up and at present is headed by Dr. Lovelace, a civilian physician with considerable aviation background. It also includes several other civilian members and the surgeons general of the armed services.

The Medical Council passes on hospital construction and also determines the number of beds authorized for each hospital. A special agency, the ASMRO regulates the disposition of incoming casualties and the transfer of patients from one hospital to another except that within a given district we can effect transfer without reference to that office. We have felt somewhat dubious about ASMRO and it remains to be seen whether it will function as promptly and responsively as desired at peak loads and with as few people. Currently we supply it with more help than we formerly used to run our own hospitalization office.

Army and Navy medical procurement has been consolidated for the last few years and is working well for the most part. We still retain our own Supply Depots. These by the way are being placed under S and A for further consolidation of purchasing and management. This will probably effect some conveniences but savings in personnel we hardly anticipate. Needless to say we will cooperate fully and wholeheartedly in making these innovations work whether we like it or not.

Coming at last to our own function, we must remember in considering future possibilities, we have to think in terms of casualties far beyond anything we have ever dealt with before, and also possible destruction of certain service facilities. The central agencies will need help and again they may even be knocked out. We stand ready to fill in the breach or rather prevent a break in operational functioning. To this end we keep records of our hospitals and larger infirmaries as to patient loads, vacant beds, expansion possibilities and personnel assigned. We also keep a card index of all recorded civilian and Federal and State hospitals. We receive reports from the Army as well. We are thereby in a standby position to aid in adjusting hospital loads, flow of patients and utilization of personnel, in the interest both of patient welfare and the efficient, economical use of our facilities.

Daily reports of patients and staffing are received from our hospitals and from them we compile a weekly report of hospitalization and also of medical personnel in each district.

Organizationally the medical officer comes under logistics since that is the major concern. The functional outline of duties is as follows:

1. Acts as advisor to the Commander in medical matters.

2. Represents the Commander in professional matters, as appropriate and directed.

3. Carries out such visits, consultations and inspections throughout the Frontier districts as necessary and as directed.

4, Gives assistance in medical aspects of ESF planning and logistics.

5. Reviews medical aspects of all plans submitted to or developed by ESF.

6. Liaison with BuMed, DMO's, Procurement Agencies, with reference to planning, logistics and various local problems.

7. Maintains sufficient files to provide adequate and up-to-date information on medical situation, to form the basis for aid, cooperation, recommendation and such action as may be needed or ordered.

8. Liaison and cooperation with the Medical Officer, Atlantic Reserve Fleet.

9. Aid in medical care of ESF personnel.

10. Aid in maintaining good public relations particularly in the medical field.

11. Keep ESF personnel advised on medical matters of naval and general interest.

In conferring with District Medical Officers, the main points of interest are about as follows:

1. Status of Plans particularly as related to BuMed Facilities and BuMed NCL Plan.

2. Reserve Personnel of Medical Department, including MC, MSC, NC and HC.

3. Hospital Expansion possibilities and plans, including Shore Station Development Board and Mobilization Planning Projects.

4. Dispensary and Infirmary Expansion, including Shore Station Development Board and Mobilization Projects.

5. Dependents Care.

6. Reserve Supplies and Storage Facilities.

7. Miscellaneous
   - (a) Blood Donor Program
   - (b) Contacts with other Services and civilian professional groups.
   - (c) Transportation

(d) Any other problems or conditions ESF should be aware of or might help with especially as regards hindrances or handicaps involving state of readiness for war.

As I hope is apparent the idea here is not only to coordinate and integrate as we say in these days, but to stand ready to help in any capacity we can.

NOTES ON ATOMIC MEDICINE

ALUMNI BROOKLYN HOSPITAL, NEW YORK

10 April 1952

SOME MEDICAL THOUGHTS ON CIVIL DEFENSE

May, 1952

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PREPARED May, 1952

Medical & Civic Problems in Special Weapons Defense

~~SOME MEDICAL THOUGHTS ON CIVIL DEFENSE~~

There has been an ever present need for some measure of communal ~~Civil~~ Defense against disasters since prehistory ~~from the ancient~~ days when mankind first developed a communal type of existence and particularly since the advent of large cities. ~~In other words, the need for civil defense is pre-historic in derivation.~~ The diversions and opportunities of city life have always had an irresistible appeal for many ~~to most~~ people despite fulminations against the immorality and viciousness often rampant in cities and again despite all the poetic raptures anent a ~~praise of~~ simple frugal life in the country; at all events ~~and so,~~ great concentrations of human population have featured human existence throughout all recorded history. Due to the resulting increase in vulnerability, fires, floods, storms, volcanoes, earthquakes famine and pestilence have all taken frightful toll; add finally warfare. Mankind has an unhappy predelection for settling serious and heated disputes by violent and desperate means; quite a few rulers have proven ~~of us are~~ not at all adverse to murderous

means of gaining power, wealth or territory. Wherefore wars and rumors of war have been perpetual; and once war starts indiscriminate blood letting is just around the corner. Fury mounts, compunctions vanish, and conscience takes a vacation. Finally, stern necessity, ~~real or fancied~~, may call for wholesale destruction which would ordinarily be repugnant or unthinkable. At all events regardless of speculations, the hideous record is there and we have no reason to feel that we have seen the end of it.

As we scan the pages of history the sum total of catastrophe is impressive, in fact staggering. However, disasters usually strike rather haphazardly and in a given locality infrequently. We tend, therefore, to neglect earnest consideration of them, and avoid the trouble and expense of preparedness unless the Sword of Damocles is right over our own heads.

Well, it is over our heads now - there can be no doubt of it. With the flash and the rumbling roar of the nuclear

explosions in Japan, all the elements of mystery, sensationalism, spectacular horror and gruesome destruction of life, combined to shock complacency. Nevertheless, we still seem to find it difficult to accept the imminence of peril though there is obvious need for realistic preparation on a large scale. There is endless planning, much writing and plenty of talk - all of which is important and essential, but ~~the~~ it is time ~~to~~ we really ~~go~~ went to work, ~~is now~~. seriously.

That is not to say that we are sure to be bombed and that very soon. It is to remind ourselves that the capability is now there. We find ourselves confronted by an imposing collossus possessing great military ~~potentialities~~ strength, and wishing us no good. It seeks to dominate. It seeks to overawe and cultivates an aura of invincible might. It depicts itself as the sole repository of political and social wisdom and virtue. It obviously seeks world dominion and we are very much in the road. Moreover, a

heavy handed police state can't ~~well tolerate~~ relish free and well to do neighbors - there are too many glaring and tempting comparisons for its own people.

A healthy regard for the military and industrial capabilities of our own country has exercised constraint and aside from that the ruinous prospect of two huge countries hurling long distance atomic thunderbolts at each other's vital targets is even more idiotic than the more conventional warfare which has marred the face of the world. It is probable too that this latest group of would be world conquerors still hopes to ruin us by impaling us on the horns of a dilemma: prepare in full measure and wreck your economy; neglect preparation and become ripe for defeat. There has long been hope and expectation in the red world that our economy will fail in a complete debacle. Then comes the revolution with ~~Moscow~~ Communists pulling the strings. Accordingly, certain factors tend allay fears of early major warfare. It should be realized, however, that hope must not become a too confident expectation.

We have been disobliging enough not to collapse and now we are in a tense struggle near the edge of a precipice where some provocation may prove too much of a push in the wrong direction. Again out of grandiose conceptions, overweening conceit, poor perspective and impatience with the cold war may come the last act. Finally, desperation over internal problems can predispose to risk all on the throw of the dice of war.

We must, therefore, consider war with special weapons as a serious threat and prepare accordingly. Our military effort has, of course, been stepped up as the result of the hostile actions and provocations in recent years, and this acts as a deterrant. It can also be pointed out that a well arranged civilian defense acts in similar manner. The minimizing of damage, casualties and panic makes a vast difference in end results, and these in turn will influence the calculations of an enemy considering desparate ventures. The better our C.D., the less likely we are to be obliged to use it in war.

So then, what is the enemy likely to attempt with special weapons and how is he likely to employ them? An answer to this in general terms can be derived from current knowledge.

You can read that the Russians have made and are making atomic bombs including the hydrogen type; that they have had successful tests.

You can read that they are well up to the front in aviation and have long range bombers.

You can read that complete interception of hostile bombing planes is not possible.

You can read that they are well acquainted with Chemical Warfare including the nerve gases.

It is obvious that they must be familiar with the German type of guided missiles.

It is known that they have lots of submarines.

There is no reason to believe that they are neglecting Biological Warfare or Radiological Warfare.

Where does this leave us?

Well, as an enemy surveys the possibilities of a surprise attack, it would seem quite likely that he would decide to make it as heavy, overwhelming and suddenly as possible. It would seem to his advantage to destroy and demoralize as much of our industrial and shipping capacity as possible in this first blow, before he might find himself handicapped by our retaliatory thrusts.

Since the greatest amount of destruction per plane is apt to result from "A" bombing, it is generally thought that primary emphasis would be on these weapons.

That appears valid and should be coupled with the idea that a number of bombs are likely to be used against large important targets. There is also reason to expect that some submarines built to handle guided missiles might be employed to hurl atomic weapons at coastal cities.

This leaves us with Chemical Warfare, Biological Warfare, and Radiological Warfare. A complete evaluation of this would

be too time consuming here and one can only say - don't dismiss them entirely from your minds. One or more of them can be employed along with atomic bombs to increase demoralization and impede rescue and rehabilitation. Mass casualties, too, are possible with Chemical Warfare. Radiological Warfare can have a great nuisance or harrassing value. Biological Warfare has possibilities and lends itself to sabotage.

Coming now to the medical aspects we find our central problem is one of magnitude. Elaborate calculations have been made, based on Japanese records. These must be taken with realization that considerable variation is possible based on size and effectiveness of the bomb, time of day, type of weather, elevation of burst, types of structure, provision for prompt rescue and medical care, and finally but far from least, advance warnings. Nevertheless, in any case the number of casualties will be huge. The usual estimate per "A" bomb in a a populous city is 120,000, with about 80,000 surviving the

first day and 60,000 surviving in all. This brings us to the need for a lot of special considerations which are worth highlighting:

<u>Clear designation of authority and workable organization</u>

<u>Adequate logistic planning</u> & Stock Piling.
well thought out local planning.

<u>Damage Control</u>. ~~Essential not only to control fire but cope with all damage on an emergency basis. Develop~~ Special squads, are often indicated, such as we have in the Navy and whose efforts have saved many ships and lives. Large industrial plants should consider this possibility-

<u>Rescue</u>. Special training for rescue crews is necessary to avoid dangers in working amid wreckage and rubble; also proper handling of casualties.

<u>First Aid</u>. Widespread instruction is needed - in fact it should be universal. What to do and what <u>not</u> to do also. Resuscitation methods have been improved and need to be taught. Usual first aid supplies in the home should be supplemented with a flash light, canned milk and food (several days supply), matches,

candles, heavy gloves, rope. Sheets and blankets should be readily available. A sterno type stove is an excellent adjunct. Keep a few tools handy where they can be picked up readily.

Medical Supplies. These are listed in various books and brochures. A thing to remember is ample supplies for dealing with hosts of minor injuries. Proper treatment of these will prevent future complications and keep many more people available for duty.

Mutual support from adjacent areas & mobile Units

Transportation. All sorts of ambulances and conveyances should be available, but don't forget jeeps and helicopters, motor scooters and bicycles. Proper equipment for resuscitation and for clearing air passages should be part of all ambulance equipment.

Supplemental Hospitals. Schools are given first choice for more serious cases because of wide distribution and type of construction - few stories, large rooms, wide corridors and stairs,

frequent presence of some type of commissary installation.

Hotels provide excellent accommodations but present difficulties on the score of possible elevator failure, narrow corridors and many small rooms. Individual survey will indicate value. They may often be out of commission due to concentration in the heart of the city where destruction is more likely.

Airport hangars may serve well as emergency field hospital sites.

Tent hospitals are often seriously considered. It should be remembered that tents deteriorate in storage, are laborious to set up and provide flimsy shelter.

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<u>Blood and Blood Substitut~~ions~~es</u>. The need for whole blood and plasma will exceed supply and involves thoughts of plasma extenders or "blood substitutes". They are still ~~a matter for~~ subject to continued research but it ~~appears evident that much good can be accomplished by these agents, and we should prepare to make use of them.~~ ~~has become evident that~~ they are very useful. #

Dextran has now been adopted by the armed services as a substitute for blood plasma

(Dextran, Periston and Oxypolygelatin)

<u>Burns</u>. Special dressings are advocated and excellent types have been developed for the closed method of treatment which is generally preferred. Quite likely there will often be insufficient dressings or people to do the dressings required for the closed pressure method and Admiral Willcutts recommends standardization of the open method. Aluminum powder, it might be mentioned, has been used by Wachsmuth in Germany with good results. Cortisone appears helpful in many severe cases.

Recent CAPT Spangler at the Naval Hospital, Portsmouth, wrote up a hopeful innovation which promises well. It has been developed by Dr. Curtis during the past 10 years. It involves the use of two materials: (1) a gel compounded of partially hydrolized casein, sodium lactate and sodium lauryl sulphate. (2) A four ply gauze dressing impregnated with zinc acetate. The gauze is applied in strips after the burn is covered with the gel (1/16 inch thick) and is secured with elastic bandage. Dressing allowed to remain 10-14 days. The gel is named Zinax

(U.S. Armed Forces Journal, Vol. III, No. 1, January, 1952, pp. 105-14).

Inoculations. Regard must be had for cases of serious radiation exposure. These do not respond normally and should not be included in mass inoculation procedures.

Brown

Nerve Gases. These pose a very serious threat. Atropine is the ~~principle~~ principal remedy and must be given promptly and frequently. ~~Terminal~~ severe asphyxia ~~will call~~ may develop in these cases ~~for~~ and resuscitation measures need to be widely known.

Biological Warfare. This Calls principally for alertness and ability to carry out prompt identification studies by laboratories. There is virtually no liklihood of epidemics being caused among our people. Our regular city & Public Health Labs can serve well & there is no need for panic.

SKIP

Conservation of Dressings and Supplies. In this country we tend to be notoriously wasteful and it is well to remember that surgery can be done without drapes and without dressings other than perhaps a thin piece of gauze stuck on with Co. Tr. Benzoin. This is, to be of course something for everyone to think of primarily but primarily it to indicate that no one need feel that he is being dangerously neglected if surgical dressings should be very scant in some emergency situation.

Anesthetics. Just one notation. Chloroform is almost a forgotten anesthetic. Admiral Willcutts points out that this

can be used to advantage, especially when dealing with mass casualties. It is swift and effective in small amounts, is non-inflammable and is relatively pleasant.

Resume

<u>Radiation</u>. This falls within my own particular province and aside from that, involves so much confusion and misapprehension that I think I may dilate upon that subject with some profit.

In my lectures on radiological safety I like to note that there are both of over & underemphasis making one recall ~~the~~ perils ~~of radiation are akin~~ to the Scylla and Charybdis myth. One finds grossly exaggerated fears based on serious effects to be sure, but puffed up by wild stories and vivid imaginations and involving the possibility of serious panic, interference with important projects, wasted effort and needless expense. Some people are worrying about Geiger countries Counters when they could more profitably think of how to deal with conventional perils. On the other hand, neglect of radiological safety has produced martyrs to science in the past, and is still producing victims of ignorance and recklessness as well as accidents today. Serious problems in radiological defense

are also involved and so let us evaluate that hazard a bit closely.

The Place of Radiation. The relative importance of radiation in causing casualties is usually estimated at 15-20% as compared to 60% for trauma and 60% for burns. Obviously there will be many cases afflicted with all three and it appears likely that radiation as a complication has ~~very~~ extremely adverse effects. It is apparent too, that since prospective casualties are roughly estimated at 120,000 for a bomb in a populous city, that the immediate concern must be for rescue, first aid and care of shock, burns and ordinary trauma. The serious radiation effects come on later. This picture, of course, has reference to the type of explosion produced in Japan. If an underwater burst is used, the radiation problem will be of primary concern since there will be a deluge of water and foam laden with radioactive fission products. It is generally thought that air bursts are more likely since destruction is greater. An underwater burst

is not likely to duplicate the extent and degree of contamination seen at Bikini, when we carried out such a test. This is because a considerable depth and a large volume of water are requisite. A convenient lagoon or its equivalent made to order, is not conveniently at hand in many places. nevertheless a nasty mess could be made to deal with where there are large harbors

A number of radiations are involved but basically they all show a similar type of action in that they produce effects by ionization. As the result of ionization, there are changes wrought in chemical compounds and those in turn interfere with the normal metabolism of cells. Enzyme action is affected, chromosomes are damaged, and formation of new cells especially disordered or possibly checked entirely. In other words, those radiations which we characterize as ionizing are irritant in effect which means that in excessive dosage they lead to inflammation, degeneration, and necrosis.

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From the U. S. Strategic Bombing Survey of the Effects of Atomic Bombs on Hiroshima and Nagasaki, the following is derived:

According to the Japanese, these individuals very near the center of the explosion but not affected by flash burns or secondary injuries became ill within 2 or 3 days, and the victims expired, some within 2 to 3 days after the onset and the majority within a week. Autopsies showed remarkable changes in the blood picture - almost complete absence of white blood cells, and deterioration of the bone marrow. Mucous membranes of the throat, lungs, stomach and the intestines showed acute inflammation.

The majority of the radiation cases, who were at greater distances, did not show severe symptoms until one to four weeks after the explosion, though many felt weak and listless on the following day. After a day or two of mild effects, the appetite improved and the person felt quite well until symptoms reappeared at a later date. In the opinion of some Japanese physicians, those who rested or subjected themselves to less physical exertion showed a longer delay before the onset of subsequent

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symptoms. This appears to be a valid observation. The first signs of recurrence were loss of appetite, lassitude, and general discomfort. Inflammation of the gums, mouth, and pharynx appeared next. Within 12 to 48 hours, fever became evident.

SKIP

Commonly seen were shortage of white corpuscles, loss of hair, inflammation and gangrene of the gums, inflammation of the mouth and pharynx, ulceration of the lower gastro-intestinal tract, small livid spots (petechiae) resulting from escape of blood into the tissues of the skin or mucous membrane, and larger hemorrhages of gums, nose, and skin.

Reverting to the air burst it should be noted that although Redone

~~In general, it appears that~~ radiation caused only 15 to 20 per cent of fatalities in Japan it might ~~and would~~ have caused more if ~~many~~ more victims ~~had not died sooner from the explosion itself.~~ been rescued. Certainly there could have been more cases of radiation illness since it appears that ~~In addition, it is probable~~ that 95 per cent of the ~~people~~ survivors within a 3000 feet radius suffered in some degree from ~~radiation sickness.~~ that cause

morale

In addition to the physical effects, it is worthwhile to note something of the psychologic. Commander Thomas A. Harris reached Nagasaki about a month after it was bombed, and reported to the American Psychiatric Association in a discussion, that the terror had by no means subsided and that the people had as yet not been able to pull themselves together and work effectively. They knew many were dying of radiation illness and very naturally feared for themselves. We can see in this that morale factors must be given the gravest consideration in our disaster planning and that they further emphasize the need for effectively coordinated relief from outside sources.

Another aspect of morale problems is worthy of note - the immediate effect of severe disaster is benumbing and people will usually carry on more or less automatically for a time, in accordance with habits and indoctrination. A little later comes a period of recoil and then some individuals exhibit a temporary phase of great resentment and hostility often manifested in

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unreasonable fashion and even at times against rescue workers and other personnel trying to help them. It is well to bear this in mind and be on guard against it.

As an encouraging afternote it should be mentioned that follow-up of Japanese radiation casualties who recovered, show them to be getting along very well. It should also be noted that many sensational accounts, usually involving monstrosities, are not true.

SKIP

What most of us are interested in are questions of safety and this, it should be noted, applied to some aspects of everyday life as well as disaster.

Pause

Coming now to radiological safety it is interesting to note that In the early days of the century there was some little apprehension concerning these newly ~~found and mysterious~~ discovered x rays + the rays from Ra. rays, but, unfortunately, fears were largely absurd and misdirected. Scarcely anyone seemed to realize that there might be biological dangers. Instead, the public was treated to imbecilities. Thus, in the Pall Mall Gazette, it was stated: "We are sick of Roentgen

Rays. It is now said that Mr. Edison has discovered a substance - tungstate of calcium is its repulsive name - which is potential, whatever that means, to the said rays. The consequence of which is that you can see other peoples' bones with the naked eye - on the revolting indecency there is no need to dwell. It would be best to burn the works on these rays, execute the discoverer and whelm all calcium tungstate in the ocean. Let the fish contemplate each others' bones if they like, but not us."

In New Jersey, a congressman introduced a bill prohibiting use of x-rays in opera glasses. In London, X-ray proof underwear was advertised for women. Punch came out with a satirical poem to the effect that radiographers should leave people alone and confine themselves to spooks. Thus there was plenty of ridiculous concern but very little sensible thought. It required quite a few years & many victims before good safety standards & ~~a~~ satisfactory measurement units were established

~~After some years and much later than desirable, a unit was established and eventually standards of permissible dosage. This~~ The unit now employed is the "Roentgen" or simply "r". It is based on the production ~~of~~ by the radiation ~~X-ray~~ of one e.s.u. of ionization in one cc or 0.001293 gm of air.

In order to apply this figure to other types of radiation we resort to equivalence of ionization energy and biological effects and so we have the terms "REP" and "REM". The term REP stands for roentgen equivalent physical and is defined as the amount of ionizing radiation that is capable of releasing the same energy in tissue as 1 r of x or gamma. This amount is 93 ergs per gram (an average) and is associated with formation of 1.6×10^{12} ion pairs. The term "REM" stands for roentgen equivalent man and is defined as the amount of ionizing radiation which when absorbed will have the same biological effect as one r of x or gamma rays.

SKIP

The upper limit of permissible dosage for generalized exposure has been set at 0.3 r per week of x or gamma rays per day (or the physical equivalent in effectiveness of other radiations)

Resume

It should be noted, however, that this dosage limit is for workers who are continually exposed to some degree of radiation in their daily occupation. It does not have practical application to occasional exposures. There is a pronounced tendency to confuse this type of work-a-day standard with

practical limits for occasional clinical exposures or those required for emergency or military necessities. The result is that there is much needless alarm and worry; also increased susceptibility to panic - a most important factor. Let us remember that we receive more than 0.3 r in many clinical applications of X-ray and radium - often much more. In the heavy exposures which might be involved in atomic warfare and related action, we think in terms of so-called calculated risk involving dosages extending from a few r to hundreds along lines about as follows:

Up to 5 r	negligible
Up to 50 r	of little ~~immediate~~ importance: Possibly some mild effects.
50 to 100 r	increasing incidence of minor disability: People still able to carry on.
100 to 200 r	increasing incidence of ~~severe~~ illness ~~cases~~: Victims likely to become casualties.
200 to 600 r	increasing mortality. Serious and critical cases frequent. L.D. 50 at about 400-450.
600 r + ...	Recovery unlikely ~~Lethal outcome virtually certain~~.

This applies to radiation received in the course of a few minutes or hours. When radiation is received over weeks and months, figures have a different significance and the total cumulative dosage can be greatly increased without severe effects. In certain diseases, 50 r of generalized body radiation have been given several times a week up to 500 r without alarming or dangerous radiation effects. ~~In general,~~ However, it is ~~usually felt~~ considered that all exposure should be minimized and it is probable that about two hundred r of generalized or total body exposure is about all that can be absorbed with relative impunity even in small increments such as 25 r weekly.

~~As regards some practical safety limits, the following points can be made:~~ Time does not permit of much more elaboration but following a few points seem worthy of mention

1. Radiation effects from a bomb persist for several seconds until the fire ball ascends out of range and also cools down. Thus, a prompt avoidance action is possible and may be

life saving. It may be possible to dodge behind something or at least to curl up on the ground, possibly behind steps, in doorways, etc. SKIP

Reduce

(1) 2. In the case of an air burst, persistent radiation effects or fall out are of little or no practical concern in rescue work.

(2) 3. In the case of contamination from underwater or underground bursts, it is to be remembered that the radiation from fission products although intense at first, diminishes rapidly, so ~~that means~~ that a delay of a few hours or even thirty to sixty minutes in emerging from shelters or entering contaminated areas will reduce exposure enormously.

(3) 4. Radiological warfare is frequently mentioned in very serious and, at times, exaggerated, terms, ~~is most apt to prove a nuisance and panic weapon~~. It sounds easy, in popular accounts, to make a city permanently uninhabitable ~~for years~~ but it is just not so. In addition Orderly evacuation from contaminated areas is readily possible. The greatest peril is that of panic, which could readily produce far more casualties than any R.W. agents.

As noted in "The Effects of Atomic Weapons" (page 287) radioactive material can be obtained from fission products formed in the pile or by purposeful irradiation of elements placed in the pile. A nuclear reactor in the course of 100 days (million watt output) might produce about one megacurie of activity. This spread over a square mile could produce 200 r/day of 1.5 gamma at 3 foot level .... (gamma rays would be the most effective radiation to use).

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It is easy to see that it would not be simple to use nor too cheap.

The manner of use has of conjectured as being in the form of "death" sand prepared by drying a solution of fission products on very fine sand or metallic powder, which might not be readily detectable as it settled.

Resume

In general, advantages relate to general harrassment, ~~denying~~ denial to an adversary ~~use~~ of given areas or facilities for a time, interruption of work, possible production of panic, and

frequent time consuming + expensive

necessity for decontamination. Disadvantages relate to decay (limited half life) ~~and~~ with resultant difficulties in stock piling and need for constant renewal; difficulties in separating the most desirable fission products; shielding of personnel charged with responsibility of delivery; effecting adequate concentration in the desired areas; diversion of pile function from production of fissionable materials.

This brings my rather sketchy coverage of medical problems to an end. I would like now to close with the reminder that huge as the problem is, there is much we can do and must do; that by so doing we will be prepared to save thousands of lives and at the same time aid in the prevention of war by disabusing enemies of the idea that we will easily be knocked out by A bombs or any combination of special weapons. A "pushover" is always a temptation for a bully.

We have taken tough knocks before and can take more if we have to. This time let us be ready.

Brookhaven
Oct 20, 1952

LECTURE NOTES ON

PERMISSIBLE DOSAGE AND CALCULATED RISK

1952 Revision

PERMISSIBLE DOSAGE
AND CALCULATED RISK

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LECTURE NOTES ON

PERMISSIBLE DOSAGE AND CALCULATED RISK

By

Rear Admiral C. F. Behrens, MC, USN

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In ancient days the risk of running into serious danger while trying to avoid its opposite type was depicted in the myth story of Scylla and Charybdis. It was necessary to sail a careful course right down the middle, to escape the monsters inhabiting those rocks. This myth is always a very pertinent one and we can see it very well exemplified in the field of radiation hazards. We find those who would shrug off radiation dangers perhaps in the spirit of Ajax defying the lightning, but more likely in the mood of finding it difficult to attribute physiological importance to the more insidious things which our senses do not detect. On the other hand, we find those who having learned of rather gruesome radiation effects, have developed an overweening dread both on individual and collective scales so that they see the doom of the whole human race rushing on in a demoniac avalanche. This pessimistic view has been in ascendency since the days of Hiroshima and needs correction.

There is obvious danger both in overemphasis and underemphasis. Excessive fear can impose disastrous handicaps on operations and also cause panic with frightful consequences. Disregard produces needless casualties and stores up much trouble for the future. Radiation can prove a subtle agent of mischief and not infrequently a disguised assassin.

In the early days there was some little apprehension concerning these newly found and mysterious rays, but unfortunately fears were largely absurd and misdirected. Scarcely anyone seemed to realize that there might be biological dangers. Instead the public was treated to imbecilities! ~~Thus,~~ The Pall Mall Gazette considered x-rays revoltingly indecent. Punch poked fun at Roentgen and advised him to work on spooks. A N.J. legislator was concerned about the use of x-rays in opera glasses. In London, x-ray proof underwear was offered.

Ill effects were usually blamed on such things as ultra violet from the Crookes tubes, platinum particles, cathode rays, electrostatic discharges, heat and so on. It was soon noted that erythema was frequently seen involving the hands, arms, and faces of people working with x-ray apparatus, but it appeared that this was considered of scarcely any more importance than sunburn. Thus, before long a tragic list of disastrous consequences began to unroll and nearly all the early workers appeared as victims, many of them fatally injured.

Doctor Kassabian wrote of x-rays as an irritant in 1900 and described his own case: "About five months ago the fingers, knuckles and dorsum of left hand exhibited a general erythematous condition. This continued about a month; the itching became intense, the skin became tough, glossy, edematous and yellow." His condition became worse and in 1903, he again wrote, "In order to effect a cure I have used every remedial agent mentioned in all the text books - but nothing seemed any good". In 1908 an area of ulceration showed malignant changes. In 1909, in spite of amputations, there were

axillary metastases and death soon followed. This story with minor variations could be told of many others there is not time to mention.

When radiation dermatitis sets in, there is inflammation, swelling, loss of hair, dryness, and also atrophy of finger nails. Histologically, there is eventual replacement of normal collagen by a dense hyaline type, obliterative changes in the blood vessels and atrophy of glandular structures. Repair efforts are irregular and inadequate, resulting in keratosis, warts, and telangietases. Inevitably there ensues increased susceptibility to injury resulting in abrasions and ulcers which heal with great difficulty and ~~eventually~~ frequently develop ~~incidence of~~ malignan~~cy~~t changes.

In this day and time we do not ~~usually~~ expect to see such extreme effects in workers and we keep an eye open for early injuries. None-theless, let no one believe that the drastic changes are a thing of the past. Ignorance, carelessness, and forgetfulness are always with us and not all people employing x-rays and other ionizing radiations are well trained. Some have virtually no training at all, and we also find unscrupulous quacks and even so-called beauticians who will occasionally use x-ray - ignorant of and indifferent to dangers. Finally, scientists and medical men in their enthusiastic use of radioactive materials still take undue chances with themselves as victims.

Early signs that we watch for are:

1. Increased susceptibility of the hands to chapping.
2. Brittleness and ridging of the nails.

3. Blunting or leveling of the finger ridges.

4. Changes in terminal capillaries of finger nail folds.

5. Dryness and epilation. insert here

Hematological Considerations. It has been recognized for years that lowered blood counts resulted from exposure to ionizing radiation and this has been the basis for requiring periodic blood counts on people working where radiation hazards are involved. The leucocyte count is first affected, but the red count soon follows, the difference being due not to lesser susceptibility but to the longer persistence of individual rbc in the blood stream (about 120 days as compared to a few days for leucocytes and a matter of hours for lymphocytes). There are also the following tendencies in the case of long time exposure: Hypersegmentation, shift to the left & cross over between lymph & granulocytes. Bilobed lymph also mentioned. Occasionally there is hyper-reaction with leucocytosis ~~and~~ an absolute lymphocytosis. Reticulocytes may go beyond 2%

Statistically, average changes are manifested very early but in the case of individuals, early changes are often hard to evaluate because of the variations in counts, even in the same individual and from hour to hour. stop

Thus ~~there is now~~ has been much thought given to relaxing the customary ~~[illegible]~~ practice of periodic blood counts or even of abandoning entirely, requirements for periodic blood counts on radiological workers. It is ~~felt~~ realized too that modern safeguards and use of personnel dosimetry ~~further~~ greatly diminishes the need for blood counts. ~~Nevertheless~~ ~~such~~ On the other hand blood studies ~~may help to prevent serious~~ have a valuable place: overexposure and enable us to call for withdrawal of individuals with blood abnormalities which might be aggravated by radiation or perhaps falsely blamed on radiation.

See new sentence

It is to be remembered too that consistent or heavy exposure to radiation involves a distinct increase in the incidence of leucemia; that some workers are prone to ~~certain people~~ neglect or evade usual precautions; that some people may be unduly sensitive to hematological ~~hematological~~ effects. Thus it is my own belief ~~believed~~ ~~attitude~~ that blood counts still have a place in radiological safety. Recently at a hematological conference of the Atomic Energy Research Establishment, Harwell, England, the following opinions were generally agreed upon:

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1. Blood counts are the best index of the effect of irradiation we have at present.

2. Blood counts should be made on persons exposed to radiation:

   (a) Efforts should be concentrated on those with serious exposure hazard.

   (b) Time and effort must not be frittered away on fringe cases.

3. Monitoring can reduce and, in certain circumstances, eliminate the need for counts.

   (a) Especially true in large, fixed radiation generating machine installations.

   (b) Blood counts are needed in addition to monitors in persons using radioactive isotopes.

4. Costs can be reduced by using the white blood count only as a routine examination to indicate a trend - on the assumption that the trend is the paramount consideration. Agreement was not unanimous on this item.

5. The first sign of overexposure to radiation is the cross-over between neutrophils and lymphocytes, and therefore the differential count is too important to be eliminated from routine examinations. Again there was disagreement among the conference members.

6. Repeat counts should be reduced to a minimum based on experience in each situation rather than at time intervals arbitrarily chosen.

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7. Blood standards commonly used by conference members in industrial practice

Total WBC		Poly. neutr.		Lymphs.	Abnormal cells	Interpretation or action taken
4500	or	3000	or	1000	any	Warning. Repeat before hiring new worker. If on the job, keep at work and repeat at short intervals.
3300						Harwell will hire if otherwise O.K.
3000	or	2000 - 2500		750	numerous	Do not hire. Remove from work, complete clinical workup.

OMIT

It was pointed out that no research has been directed toward a "warning level", the figures of which have been arbitrarily established.

8. Study should be made of the "physiological low" incidence (about 5%) found in the general population with special regard to stability (Technical Report, ONRL-125-51, 12 Dec 1951). (The above notes on the hematological conference were taken from the Medical News Letter, Volume 19, No. 3, 8 February 1952.)

Note copied from revision text for Glasser's Med.   ~~omit~~

The matter ~~[illegible]~~ sums up about as follows:

In well protected installations and where personnel monitoring is practiced, the role of blood counts becomes minimal. In fact some authorities now recommend complete elimination of routine counts for radiation workers. Stone reviews the matter in his excellent "Carman" lecture on "The Concept of a Maximum Permissible Exposure" published in the May 1952 issue of Radiology; he favors elimination of the requirement. On the other hand, as recorded in the Naval Medical News Letter of February 8, 1952 (Vol. 19, No.3) at a Hematological Conference at the Atomic Energy Research Establishment, Harwell, England, it was felt that blood counts should be made but efforts concentrated where there are serious hazards; monitoring should reduce and in some instances eliminate the need for counts.

~~It would certainly seem a good idea that~~
~~as a minimum the~~

However even ~~then~~ ~~if~~ in such instances it would not be amiss to include blood counts in pre-employment & other physical exams of ~~[illegible]~~ workers exposed to radiation

Blood counts thus still have a valuable place for employing them

~~In the matter of carrying out blood counts in radiological workers~~ it is well to establish a base line for each individual ~~before work is started or there has been a chance for significant exposure to accumulate.~~ by employing several counts ~~are needed for this purpose,~~ ~~as well as~~ a well-standardized ~~and careful~~ technique. ~~A most~~ They should be made ~~important feature is to make counts~~ at the same time of day, perferably with ~~the subjects in~~ fasting subjects. ~~state.~~ Since it is ~~not~~ seldom practicable to have personnel report without breakfast, the best time is usually just before lunch hour. The frequency of counts should depend on circumstances and should be a part of all periodic physical exams. ~~The Navy presently calls for a count every four months.~~ Various ranges of permissible variations and limits calling for interdiction of exposure have been set. Ordinarily these should not be regarded as absolute ~~; rather, we might well regard them~~ but as levels beyond which ~~serious~~ evaluation of individual circumstances is in order. The ranges presently adopted in the naval service are:

WBC	4,000 - 12,000 per cubic mm
RBC	3.5 - 6.5 M
Granulocytes	55 - 80% or 1,000 - 7,000 absolute number
Lymphs	20 - 40% or 1,000 - 4,000 absolute number

[illegible] <u>Genetic Effects</u>. ~~Coming now to~~ In the genetic effects we ~~reach~~ have a field of intense concern ranging from the ridiculous to the most profoundly important. One bugaboo can be dismissed abruptly and that is fear of impotency. There is considerable confusion between sterility and impotency, and perhaps this is not without salutory effects in that it should tend to discourage recklessness. However, the fact remains that impotency is not caused by ionizing radiation,

except insofar as this may be secondary to the general exhaustion of victims in extremis or to psychic aberrations in which a radiation phobia plays a part. new material (page 3)

Our principal concern is with various types of mal-development resulting from mutations. Dosages of about 500 to 700 r received in a brief time (acute exposure) are required to produce permanent sterility. This means that most persons so affected by such a heavy dose of total body radiation would be fatally injured and die. Again ~~we need have little concern about gross monstrosities.~~ only [illegible] Heavy dosage of radiation is ~~far~~ more apt to cause fetal death and miscarriage than monstrosities However, there is ~~some~~ evidence ~~to suggest~~ that radiation of the pelvis of any considerable degree during early pregnancy may tend to produce microcephalic idiocy.

Radiographic exposures within usual diagnostic scope and under proper supervision need cause no concern.

Regarding effects on future generations, satisfactory precision is lacking for human subjects, and one needs to be cautious and tentative in applying quantitative date from experiments on other species to ourselves. Nonetheless, we must bear in mind the following:

~~1. Mutations are increased by ionizing radiation due to effects on the genes and chromosomes.~~

~~2. There appears to be a very high degree of cumulative effect.~~

~~3. Mutations are unfavorable except in a very small proportion and being mostly recessive may not manifest themselves for~~

Infant death
Mutation
Effect on Early gestation

New material

1. The hereditary patterns of living organisms are subject to mutations due to changes in the genes governing development. As mentioned by Plough in Nucleonics, August 1952, the number of genes is estimated at 20,000 for the human species and the spontaneous mutation rate variously estimated at from 2×10^{-5} to 10^{-7} per gene per generation. The high estimate would indicate the probability of one new mutation in almost every individual (0.4 mutations per germ cell); the low would suggest 8 in every 1000.

2. Mutations are increased by ionizing radiation. The dosage factors for humans involve extrapolation and estimates of the radiation required to double the spontaneous rate have varied widely from a few r to hundreds. Citing the work of Russel, Plough mentions a mutation rate in mice of 2.5×10^{-7} per gene per r and figures that 32 r would double the spontaneous rate. The rate for humans is likely to be roughly comparable and the dosage to the gonads to double our mutation rate is likely to be under 100 r and possibly as low as 30.

3. Genetic effects from radiation are cumulative to a very high degree.

4. Mutations are unfavorable except in very small proportion and being mostly recessive may not manifest themselves for a

new material

number of generations. Lethal and extremely unfavorable mutations tend to be wiped out due to early death, at times in the embryonic stage. These, however, are probably less than a fourth part of the total. The remainder, mostly recessive, are passed on to succeeding generations and may at times manifest themselves in the guise of some more or less obscure physiological aberrations which may weaken but not necessarily kill the individual outright. Differentiation from incidental disease processes, in such instances, may prove difficult and uncertain.

5. Mutations from ionizing radiation do not appear to be of specialized types and cannot be recognized by specific characteristics; and in considering possibilities, it should not be assumed that the matching of a pair of recessives requires that both be derived from radiation.

6. The present burden of unfavorable mutations carried by the human race is heavy and should not be increased. It may well be that from the standpoint of general welfare, unless a large percentage of the population should be involved, there is little cause for concern; nevertheless it is not permissible to overlook the increased possibility of eventual tragedy to individual families.

~~Coming now to practical significance it can be said that~~ There is compelling accordingly reason for good radiological safety procedure

new material

and the avoidance of minimizing of exposure to the gonads. On the other hand there need be little concern as to routine clinical radiology provided there is competent supervision and appropriate regard for special circumstances of genetic and/or developmental importance. This latter factor is related principally to pregnancy & there is special vulnerability in the first 6 weeks

At this point it is of interest to note some of the approximate dosages we are apt to receive in the ordinary course of events

Cosmic rays and natural radioactivity: 0.3 mr/24 hrs.

Conventional chest x-ray: 50-250 mr/film entrance dose.

Fluograph of chest: 900 mr.

Abdominal fluoroscopy plus spot and serial film: 3 r in the center of the abdomen (subject to much variation chiefly by increase).

Urography: 1.3 in center of abdomen.

Lumbar spine: up to 8 r in the center of abdomen.

Pelvimetry: 200 to 400 mr/film in central area for A.P. films; 1.3 r for lateral films.

Dental film 500 mr/entrance dose.

These dosages are not alarming but it is quite apparent that it is readily possible to pile up significant exposure especially where repeated examinations are likely. There is then added reason for careful work, proper fluoroscopic techniques and good discretion. A recent and excellent appraisal of the situation is provided by Ritter, Warren and Pendergrass in the August 1952 issue of Radiology.

Best Estimates quoted by Plough of Amherst in ~~the~~ the Aug 1952 issue of Nucleonics suggest that human mutations would be doubled by 80 r at maximum. If as suspected, the human genes are more vulnerable, the correct figure is probably nearer 30 r

Thus, we are still left with much uncertainty, although it should be noted that a very low figure such as 10 r is only about the same as the total accumulation of cosmic radiation in a life time (usually 10-15 r). So it becomes difficult to be more precise than to indicate on the one hand that we should be conservative and avoid unnecessary exposure particularly when of genetic consequence, and on the other hand that there is no reason for concern over usual levels of exposure, when current safety regulations are applied under competent supervision.

At this point it is of interest to note some of the dosages we are apt to receive in the usual course of events. new material

Supplemented

Cosmic rays and gamma from natural radioactivity: 0.3 mr/24 hrs.

Gamma from back of luminous dial watches (skin contact): 100 mr/24 hrs.

Spectacle lenses containing uranium: 1 to 8 mr/hr to eyes (B).

Chest X-ray, conventional: 50-250 mr/film, entrance dose.

Chest fluorogram: 900 mr, entrance dose.

Dental: 500 mr/film, entrance dose.

Pelvis (obstetrical films): 200 mr/film in central area.

<u>Permissible Life Time Total</u>. The various harmful effects and in particular, the genetic possibilities pose the question of over-all limits. The permissible exposure limit of 0.3 r/wk would theoretically permit of a life-time exposure of 432 r, presuming thirty years service and allowing for a four week annual vacation. However, radiological safety measures reduce actual exposure below

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New material

3.17 Permissible Dosage Totals

As we consider the serious consequences and possibilities from large amounts of radiation, we inevitably come to the question of how large a life time total ~~is~~ it is safe to accumulate. It is easy to say the less the better and in fact it is always well to bear that in mind. However, that begs the question. Our 0.3 r/wk standard theoretically permits of a life time exposure of 432 r based on 30 years work at that level and allowing for annual vacations of four weeks. This is assumed to be relatively safe but decisive statistical criteria are lacking. It can be said, however, that most of the serious effects on experimental animals from protracted radiation have involved high dosage ratio and totals usually over 1000 r. Exposure of radiologists showing ill effects, is conjectural but in most cases has doubtless been very heavy. The increasing use of personnel monitoring may throw more light on the matter in future years. In general the ceiling just mentioned of about 400 r would not be too high for life time exposure and within practicable limits. As a matter of fact current safety precautions usually reduce the exposure of workers well below 0.3 r/wk so that lifetime exposure would be considerably less.

Aside from the matter of individual health and survival, we have just seen that genetic mutations are an important consideration. The increase in mutations has been described, but

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new material

it might be well to clarify the quantitative factors still further.

The low figure for spontaneous mutations was calculated at 8 new ones for each thousand individuals. Charles in NEPA Project report places the increased hazard of transmitting a new mutant at 1% for each 100 r. That means that 10 out of every thousand individuals should transmit one new mutant for each 100 r a parent has received prior to conception. This would again suggest that 100 r roughly doubles the normal rate.

The actual number of individuals affected is not large, but an increase over a long period of time would be cumulative and the noted geneticist Muller estimates that an overall increase of 25% over the spontaneous rate would eventually be disastrous.

OMIT

Figures as already mentioned are subject to gross discrepancies and uncertainties but it would seem that in view of the ever increasing numbers of people being exposed to ionizing radiation there is compelling reason for being conservative and taking some trouble in the matter of exposure of genetic consequence. A large amount of gonadal exposure can be readily avoided both in patients and workers by very simple protective measures.

The 0.3 r/wk level permits of about 15 r per year. Where conditions permit of that much exposure it would be wise not to neglect the lead apron in the case of those not

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New material

past the liklihood of parenthood. In radiological work involving the chest, upper abdomen and lower extremities lead impregnated drapes or barriers can be used to shield the pelvis.

After about the age of 45, genetic considerations are seldom of consequence and it is under consideration to increase the permissible dose to 0.6 r/wk after that age.

As a final word on the usual types of exposure let us not forget: that considerable exposure may be derived from anti-theft and anti-sabotage fluoroscopy; that readily accessible fluoroscopes may be used for diversion by people ignorant of danger; that medical people untrained in fluoroscopy may abuse fluoroscopy; that patients unless questioned may fail to tell of previous work; that shoe fitting fluoroscopy with all its inherent danger is still with us in some places; and that in general we should be on our guard against unexpected loopholes for danger.

new material

this level unless there is carelessness, and it is not established that such a figure is sufficiently low. Statistical and experimental studies of long exposure to radiation indicate some increase in the rate of aging, and increased incidence of leucemia and increased incidence of cancer. These studies, however, often involve rather high dosage rates and although they indicate a 10% shortening of life span per 1000 r, the figures cannot be properly transferred to the human species. One can only deduce that radiation does tend to produce this unfavorable result under circumstances of heavy dosage, but that the effects are relatively negligible unless excessive dosage is involved. Thus when we review the various effects we have given some account of here, with reference to the problem, we do not find ourselves with a very clear cut answer. It would seem however, fairly reasonable to say that from an individual standpoint it should certainly be well below 1000 r and probably in the neighborhood of 300 r. We can add to this, that notable concentration of dosage in early pregnancy or at time of conception is especially to be avoided.

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Calculated Risk. The advent of the revolutionary applications of what may be conveniently termed "atomic energy" has markedly increased and ~~altered~~ diversified the problems associated with the various pernicious effects of the ionizing radiations.

One of these, of particular concern in the naval establishment, relates to the possibility that under certain circumstances, personnel will have to accept exposures in excess of those we are accustomed to regard as permissible under usual working conditions. This may be

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unescapable as in an atomic bomb burst or may involve a command decision in the event of operations in a contaminated area. This feature is what brings in the element of what is customarily designated "calculated risk". O M I T

The approach to these new and unfamiliar problems is not a little befogged by phobias, conflicting tendencies, sensational accounts, "tall stories", and finally, as already indicated, a lack of sufficiently precise information.

Appraisal and clarification become therefore the order of the day and we can best start by a look at the general background. OMIT

Until recently our preoccupation in the matter of radiological safety has been along two main lines: (1) The cumulative effects of small ~~minimal accounts~~ amounts of radiation over long periods, ~~and related thereto, permissible dosages and the means of avoiding any excess over such figures. This type of concern has naturally been on behalf of long time workers in occupations where some degree of constant exposure is involved.~~ (2) ~~The second main type of concern has been for~~ The larger but more occasional exposures, of patients in clinical radio-therapy ~~radiology either radiographic or therapeutic.~~

To these categories we now find we must add:

1. Immediate effects of an atomic bomb air burst. These are well described in the publications about the atomic bombings of Hiroshima and Nagasaki and need not be recounted here.

2. Further and continued effects from an atomic bomb due to contamination by fission products or resulting from induced radiation.

This is only important when there is a subsurface or surface burst. The events connected with the underwater explosion at Bikini give us the picture. Essential operations under such conditions may well involve calculated risk exposures.

3. Exposures involved by purposeful contamination by radiological warfare agents. Such are purely in the conjectural phases and there are technical considerations which would seem to make such employment quite dubious. Yet under some circumstances, possible employment has to be reckoned with. Problems would resemble those of the second category, at least as related to calculated risk.

4. Exposures incidental to operation of nuclear reactors, more especially when and if employed under conditions when completely adequate shielding may not be practicable. These problems are not as yet well defined, but conceivably may arise in connection with nuclear propulsion.

~~These newer categories of radiological hazards relate to single or occasional exposures, or again to exposure over limited periods of time which might vary from a day to a few months, rather than to the more continuous exposure involving people continually employed in the various fields of radiology.~~ These categories ~~also~~ may involve ~~more stern and~~ inescapable necessities ~~. Thus~~ and the permissible limit of 0.3 r per week, devised to take care of customary working risks over long periods, has only limited application to this type of problem. The situation is more or less the same as in the case of clinical radiology, where different standards apply and we consider first of all practical therapeutic

necessity. For instance, in therapy we often and knowingly give dosages that involve some damage to normal structures. ~~Better a live patient with skin damage than a dead one with an unblemished hide.~~ It is, of course, a matter for careful practical evaluation of all factors.

In wartime evaluation of radiation hazards, we must be just as realistic as in the case of other perils. In the case of naval and military necessity we are subjected to deadly risks from bullets, explosives and fire in view of the surpreme need for victory and the determination that our nation and its ways of life must survive. In this perspective we must review radiation hazards from the standpoint of objectives to be gained, and effectiveness of personnel in carrying on operations - bearing in mind, of course, the probable cost in terms of reduced efficiency, possible loss of morale, and eventual casualties. From this pragmatic standard, let us now evaluate the situation as far as present day knowledge will enable us to. We can arrive at some fair approximations from the results of radiation research and therapy while we await more precise information from present day investigations.

Let us note our main concerns: First of all we are concerned with immediate effectiveness of personnel during actual operations or task performances. Secondly, we are concerned with the delayed acute effects, i.e. the ill-effects of acute radiations which come on after a latent period of from several days to several weeks. Thirdly, we must be concerned with remote effects. Fourthly, there are medicolegal matters.

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1. Immediate Considerations: In the case of acute necessity, the major thought must be for effectiveness of personnel during action. That is what first of all concerns the naval or military commander in gaining his objective. We can say that no matter what the dose of ionizing radiation, a group of men will not be mowed down as by bullets. If, however, the dosage received is near or in excess of 200 r in the space of minutes or less than an hour, effectiveness of personnel will be seriously impaired in a matter of hours. That is to say that within several hours there will be instances of nausea and lassitude akin to seasickness. However, due to common apprehension regarding radiation, the morale factor will surely be much more seriously affected. Everyone knows that seasickness is a temporary affliction, but everyone dreads what may happen to them eventually after a heavy exposure to radiation. In this regard the dissemination of the knowledge of the aftermath regarding Japanese casualties should be helpful. The survivors are doing very well as far as radiation effects are concerned, and the implication is that much of the dread of radiation is exaggerated. However, the command decision should take this morale factor very seriously. Unfavorable morale reactions in the case of radiation involve some peculiar mental hazards. These are about as follows:

(a) Fear of sterility and impotence. These are often absurd and exaggerated. Yet emphatic educational effort is truly needed here because these fears strike very deep levels and are not easily eradicated.

(b) Aura of mystery and dread. The stage has been well set to give all the uninitiated an overdose of these morale shakers and this calls for educational effort to keep the imagination from running riot and at the same time retain a wholesome respect for actual hazards.

(c) The impact of the bizarre and severe pattern of serious radiation illness. This is a practical consideration when numerous casualties are involved and is aggravated by the interim of relative well being during which victims may scatter and so produce widespread demoralizing effects when symptoms recur. It points up the need of keeping track of potential radiation casualties and also employment of the most adequate dosimetry possible.

(d) Effects of suggestion. There is wide variation in susceptibility to radiation symptoms, but when a few of a group begin to develop such, there will be a tendency for quite a few more to follow suit. Encouragement, distraction, and prompt disposal of mild cases are worth consideration here - aside from relieving a group of seriously affected soon as possible.

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Practical suggestions: It is probable that the decision of exposing people to more than 50 r on a single occasion should be based on most serious necessities, but supposing it becomes necessary to expose a command to exposures of about 50-100 r or more in a short time (hour or so): Then what? Physically, except for some incidence of nausea and perhaps vomiting, they should on the whole be able to carry on. However, morale might deteriorate. The incidence of even mild symptoms is apt at present to occasion undue alarm and the itch to get out of the affected area at once. An important consideration, therefore, is preliminary indoctrination. If there is a realization that such symptoms do not necessarily mean a serious or fatal outcome, it will be easier to handle the situation. This involves consideration of dosimetry. If one can say to his subordinates that they are not

receiving fatal or notably injurious amounts of radiation, it should prove most helpful. To leave them in an uncertain status would probably be demoralizing once symptoms began to appear. This points up the need, at least for those exercising command, to have accurate information. It is probably advisable to make provision for extending self-reading instruments at least to company level in the case of marines and soldiers. Aboard ship it should probably extend to division levels and still further in the case of the Medical Departments. It appears doubtful that such provision should extend to all individuals. They would be apt to devote too much attention and concern to this feature, and moreover they might not properly evaluate their findings.

2. Delayed Acute Effects. Following the immediate (within a few hours) effects of radiation in a single brief exposure, there is a variable period of comparative well being which, of course, is related to dosage. These delayed effects will produce serious numbers of casualties, only if the acute exposure approaches or exceeds 200 r. They tend to come on 10-14 days later and would be along the lines of Japanese casualties. Such effects relate to lassitude, GI symptoms, low blood counts, diarrhea, hemorrhages, anemia and infection. The literature on this is voluminous and there is no need for reiteration here. Suffice it to say that a Commanding Officer and his medical advisors would have the following considerations to take account of in the event of such acute exposure.

(1) Most of those exposed would be incapacitated and require hospital care within a period of a few days to a few weeks.

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(2) Heavy physical effort during any interval of comparative well being, would be distinctly harmful.

As a correlary the Commanding Officer should call for reliefs at the earliest possible moment and would have to assume that without such, his command would become non-effective, and probably a liability.

3. Remote Effects. These are related to total exposure and are relevant not only to single acute exposures but also to cumulative effects of repeated exposures to dosages below those associated with obvious acute clinical effects. Gradually accumulated total dosages may reach high figures without obvious effect. They are not of paramount importance when immediate military necessity is compelling, but should not be lost sight of. The following points can be made relative to remote effects.

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(1) Effects are proportionate to dosage and to a lesser extent to dosage rate.

(2) Nearly all survivors of radiation illness are in good condition. However, on the basis of experiments and previous experience, we can expect that large totals of generalized radiation will involve the following:

(a) Increased rate of aging (distinctly manifested in experimental animals at levels of about 1000 r. Negligible except for quite large totals (500-1000 r+).

(b) Increased incidence of leucemia (about ten times in radiologists - number of radiologists involved very small; actual risk extremely slight).

(c) Carcinogenic effects: Not well evaluated and in general slight; local effects as from beta emitting fission products more important here.

(d) Increased incidence of cataract (60-80 in Japan; a few in this country from neutron exposure): Relatively not important.

(e) Possible increase in dental caries suggested by recent work (200 r_γ) at NMRI, Bethesda, Maryland.

(f) Increased likelihood of transmitting unfavorable genetic mutations. Quantitative calculations derived from very uncertain extrapolations suggest that this increase might approximate 1% for 100 r. Not of general significance unless large proportion of population receives heavy dosage.

(g) Depending on dosage and dosage rate, there may or may not be sterility. If this results, it is apt to be temporary in males; less apt in females. (400-700 r dose to gonads within a period of a month or so is usually required).

(h) Impotency not involved. This is seen only as a temporary phase when general weakness and illness severly deplete the body or as the result of psychic disturbance.

(i) Female members of the Armed Forces who might possibly be involved (Waves, Wacs or nurses) might show

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menstrual disturbances for a considerable period and there might be instances of permanent amenorrhea. (300-700 r received within a period of several months).

(j) The quantitative factors are not well established, but it would appear that total exposures below 300 r are not apt to be of notable remote long range significance. However, if dosages of 300-400 r are accumulated in a few weeks time or less, there will also be cases of temporary alopecia and various effects already noted.

4. Medicolegal Complications. Again these would have little if any weight as balanced against military necessities, but should be considered. They would largely derive from the remote effects noted above and the natural tendency to blame all ills on anything connected with the service. The most important consideration here would be that, as far as practicable, good records of exposure should be maintained so that the possible relation of subsequent ills to exposure while in the service can be properly evaluated, and so insure a fair deal to the individual and protection of the government from unwarranted claims.

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NOTES ON REPEATED "CALCULATED RISK" EXPOSURES

The foregoing gives some account of the problem of acute exposures but there remains problems relating to repeated exposures to amounts below the usual symptomatic threshold.

Experimental studies indicate that if dosage of 10-50 r are given daily or every few days until death results, that the lethal doses will be raised several-fold, even in occasional instances to 10-fold. That poses the question as to how far we can go in that regard. First of all, we should of course have regard for the total accumulated dose regardless of time, and as indicated in the consideration of remote effects, it will be highly desirable to remain below 300 r.

As indicated by clinical experience with cancer cases in which generalized radiation was employed, daily or thrice weekly doses of from 10 to 50 r have been given without serious effects on the general health. However, there are deterrants to consider.

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a. When as much as 50 r are received several time weekly, there is likely to be some general malaise, anorexia and nausea, and headache.

b. As the total dosage mounts to substantial figures, say over 200 r, there is apt to be falling off in endurance and performances, lessened resistance to infection, poor psychological adjustment.

We must remind ourselves to think in terms of individuals who are or may be called on for supreme performances rather than in terms of patients who while receiving such dosages are under careful medical and nursing care.

Practical Recommendations

Considerable thought has been given to this matter and it appears reasonably safe to be guided by the following principles.

1. Avoid calculated risk exposures whenever possible. It is worth serious planning and effort.

2. Consider 25 r as a level within which no trouble need be anticipated.

3. Consider the 50 r zone as a safe level at which, however, mild symptoms may occasionally appear.

4. Consider 100 r as the zone where grave concern should begin in case of a single exposure. As we go beyond that level there will be casualties, frequent reduction of effectiveness, and serious morale problems.

5. The 200 r zone spells serious radiation illness to all concerned, if received in a short time. When received in smaller increments, it is a level at which close observation is needed, and effects noted above may occur.

As ~~a further~~ an aid in evaluation, the following table from NEPA Medical Advisory Panel report 1019-IER-17 compiled in 1949 is quoted.

ACUTE EXPOSURE * Estimated Results to Humans Exposed to Filtered, 200-1000 KVP x-rays, Measured in Air.

The estimates given below apply to the average normal individual. It should be borne in mind that there is considerable variations in individuals' susceptibility to radiation.

* Received within twenty-four hours.

A. 25 r and below; no detectable clinical effects.

1. From animal experiments it would appear that if man behaves like the mouse and drosophila, there will be, due to radiation, a genetic effect which is much smaller than the spontaneous rate of mutations. In other words, the combined result of the spontaneous and the radiation-induced genetic abnormalities would be slightly increased but much less than double the spontaneous rate alone.

2. Delayed effects* possible but highly improbable.

B. 50 r; slight, transient reductions in lymphocytes and neutrophiles. No other clinically detectable effects.

1. Incidence of radiation-induced genetic abnormalities is expected to be approximately the same or smaller than the spontaneously occurring abnormalities.

2. Delayed effects possible but serious effects on the average individual very improbable.

C. 100 r; at this level, nausea and fatigue may be a problem. Reductions in lymphocytes and neutrophiles with delayed recovery. Above 125-150 r, vomiting may become a problem.

1. Incidence of radiation-induced genetic abnormalities, which are quantitatively proportional to the dose, will probably still be comparable to or somewhat greater than those occurring spontaneously.

2. Delayed effects, in summation, would be expected to shorten the life expectancy of man on the average by not more than about 1% from all causes, assuming that limited observations on animals can be extrapolated to man.

D. 200 r; at this level fatalities, 2-6 weeks after exposures, might occur in a small proportion of the irradiated individuals. Nausea, vomiting and fatigue will probably occur in most persons within 24 hours. Definite depression of practically all blood elements, reduced vitality, in most cases with a convalescent period of 3 to 6 months. Temporary sterility in some cases and possibly permanent sterility in rare instances.

1. Incidence of radiation-induced genetic abnormalities will be expected to be at least twice as frequent as the spontaneously occurring abnormalities.

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* The expresion, "delayed effects", as used here, refers to any harm effects attributable to radiation on the recipient of the radiati[illegible] and manifested at any time subsequent to the period when acute reactions may occur.

2. Delayed effects - that these would be of major consequence in a small percentage of individuals would seem very probable.

E. <u>400 r:</u> it would be expected that virtually everyone would be immediately incapacitated by such an amount of radiation, and many would never recover completely. Some deaths would occur in 2 to 6 weeks.

One can add to this tabulation that 400 r is probably in the LD50 zone, i.e. the zone in which 50% of fatalities is likely.

One can also add that 600 r would almost invariably prove fatal.

Compensatory Time Away from Radiation Exposures

The usual standards for permissible doses are based on 0.3 r maximum in a week, the idea being that if a person received that much on a single occasion during that week, he should avoid exposure until the next week. This provision has a reasonable basis from the fact that spreading out the dosage of a noxious agent is always advisable. We have noted already the amount of radiation needed for lethal effects is much less when given in a single exposure than when relatively small daily doses are employed. Recovery or replacement activities are given time to operate and irreversible changes in protoplasm proteins reduced.

Another factor is that the total cumulative dose is kept within reasonable bounds and personnel are taught caution. The idea, it might be said, is not to inoculate fear or dread, but respect.

As already noted we habitually exceed the limit of 0.3 r in clinical radiation; but in the nature of things, intermittency is the usual order of events. In addition, since exposures are limited in area the 0.3 r standard for general or total exposure has little relevancy in any event.

In certain pile operations higher exposures are unavoidable. Here a limit of about 5 r is usually set following which compensatory "time out" is required.

It is possible that in the service, still greater dosages will be unavoidable and in regard to them, the principle of compensatory time out should also be employed as far as possible. A few additional considerations are offered bearing upon this problem:

1. Exposures should be minimized by advance planning and by arranging for a rotation schedule.

2. It is probable that a single exposure of 25~~-50~~ r could be disregarded.

3. In other cases compensatory time out should be arranged as soon as practicable, and for exposures over 25 r should preferably be longer than the amount given by mathematical application of the 0.3 r standard. No data presently available indicates how much this should be, but a purely personal guess might be hazarded at 25% increase for exposures of 25-50 r; 50% for 50-100 r; 100% for 100-200 r; no further occupational exposure for those who have received 200 r or more within a period of a few months. (Change of work or exceptional precautions.) ?

4. When substantial doses have been given, provision for medical follow-up should be made, including records of exposure, treatment (if any), and reports of physical examinations.

A few notes on personnel dosimetry are in order at this point. Research is being earnestly pursued in this field and we are still not satisfied with equipment presently available. A prime consideration OMIT

is, however, that for naval and military operational use, the range be sufficiently high. Most dosimetry methods are designed for the small dosages incident to ordinary peacetime operations. It is, however, possible at present to obtain a film with proper range. It is expected that pocket dosimeters of proper range will also become available before long and there are good hopes from crystal photochemical and phosphor glass methods. The Navy now employs photodosimetry in all radiological departments including industrial.

A few notes on protective garments are also worth noting. It is, of course, impracticable and would be absurd for people to go about encumbered with, say, 300 lbs. of lead armor to avoid being injured by the immediate radiation from a bomb. It is also absurd to go to other extremes and neglect protective garments entirely. Calculated risks will not involve meeting the initial high energy blast of the bomb, but rather the radiation from fission products, some of which radiation will be relatively soft and also include beta radiation. Radiologists for several generations have employed protective garments and with good effect and not too much inconvenience. It is not contemplated that precisely the same gear would be applicable to our calculative risks, but the subject is worthy of some thought in connection with particular activities and circumstances.

Our basic principle of operation should be that although we can absorb substantial doses of radiation with relative impunity, there is no point in accepting any exposure that is unnecessary or neglecting practicable means for reducing the degree of such exposure as must be accepted.

Internal hazards

The problem of internal hazards in calculated risks should be relatively minor since such risk can be avoided by well recognized means and need not be accepted except under most unusual circumstances. Inhalation hazards can be adequately handled by gas masks; ingestion hazard by familiar types of precaution involving eating and drinking and smoking. Contamination of the skin can be avoided by suitable garments.

Notes on Radiological Warfare

Internal hazards are, of course, related to possibilities of radiological warfare and since this subject is the cause of so much conjecture and moreover involves such peculiar mental hazards, it seems well to digress a bit to give the general picture.

In popular accounts one can readily derive the impression that RW is ridiculously easy. A few puffs of this stuff and a city is furnished for ages. In sober scientific calculations it becomes evident that RW is both expensive and difficult. And as for deserted cities, the facts of life as revealed at Bikini, where ships were contaminated far beyond the possibilities of RW as such, show this concept to belong in the familiar category of hair raising myths. Limited approaches began in a matter of hours and in a few days, we were working on those ships - and not, be it remembered, on a calculated risk basis but within the then permissible dosage range of 0.1 r/day.

We cannot, however, dismiss RW from calculation. It would be very useful to disrupt work and life in general in an industrial area,

and thereby cause a great nuisance, expense and harmful interruption, aside from panic possibilities which might be the most important factor of all. It should be dinned into the public's ears that any RW contamination will be promptly detected and that all hands will be able to get away from a contaminated area in good time and in most instances with negligible harm; that a panic rush will be sure to be far worse than any radiological harm.

Since, however, it is possible that under certain circumstances the use of RW might be profitable, let us go into a little more detail. In the Semi-Annual Report of the Secretary of Defense, July 1 to December 31, 1949, it is stated that

(a) "It may have the capability, if used in large enough quantities, of denying the continued occupation (although not temporary access to nor transit) of the target area for a selected period of time without destroying the facilities in that area. This would be useful in denying enemy use of friendly areas which might have to be evacuated, or in forcing the enemy to evacuate his own facilities destroying them.

(b) It has a characteristic of compactness, which increases the flexibility and reduces the cost of delivery.

(c) At present, it is a 'mystery weapon' and proper use of psychological propaganda might have great effect on poorly informed people. For this reason it is vitally important that the people of the United States be properly informed concerning the defensive aspects of RW, so that misinformation cannot cause panic.

In general, the disadvantages would appear to be

(a) The continual radioactive decay of RW agents in storage, which requires continued discard of old agents and replenishment of the stockpile.

(b) If RW materials are produced as a result of irradiation of special materials in a reactor, the use of RW must

compete with production of other atomic weapons. If the radioactive products resulting from fission are to be used, to avoid competition with other atomic applications, there are other extremely difficult and costly problems to be faced, not the least of which is the separation of desired agents from the complex.

(c) The fact that these RW agents are constantly emitting dangerous radiations makes it imperative that shielding be provided to prohibit exposure of the preparing and delivering personnel to the injurious radioactivity.

(d) The limitation on the use of RW in tactical situations, because of the delay in appearance of casualties, has been previously discussed.

(e) From practical standpoints the problem of delivery and proper dissemination is probably the most difficult problem to overcome."

This is followed by a discussion of radiological effects in Japan and Bikini which need not be repeated to this audience, and why certain contaminated ships were sunk. These reasons relate to obsolescence of the target ships concerned, costs of repairs and long distance towing, decontamination, etc., as compared to the scrap value. The section concludes with

> "It would appear extremely difficult to concentrate on attack by RW agents over any considerable area to such an extent as to cause serious injury from a short exposure. It is possible that more casualties would result from continual radiation. However, these areas would probably be evacuated. The evacuation areas would be determined by monitoring groups using instruments developed to indicate the presence of radioactivity. In this respect the Department of Defense is attempting to develop simple, rugged, reliable instruments for detecting radiation which are capable of being mass-produced for use in the field. Prior to evaculation, protection can be gained by seeking shelter inside the most heavily constructed buildings and closing doors and windows to prevent entrance of the radioactive materials."

This gives the general picture. It is of interest to relate a few more details.

As noted in "The Effects of Atomic Weapons" (page 287), radioactive material can be obtained from fission products formed in the pile or by purposeful irradiation of elements placed in the pile. A nuclear reaction in the course of 100 days (million watt output) might produce about one megacurie of activity. This spread over a square mile could produce 200 r/day of 1.5 gamma at 3 foot level.... (gamma ray would be the most effective radiation to use).

It is easy to see that it would not be simple to use nor too cheap.

The manner of use is usually conjectured as being in the form of death sand prepared by drying solution of fission products on very fine sand or metallic powder, which would not be readily detectable as it settled.

In general, advantages relate to denying an adversary use of limited areas or facilities for a time, compactness, and most important of all and as already mentioned, interruption of work and production of panic. Disadvantages relate to decay (limited half life) and resultant difficulties in stock piling; difficulties in separating the most desirable fission products; shielding of personnel charged with responsibility of delivery; diversion of pile function from production of fissionable materials.

If we are well indoctrinated and prepared, RW can have only a serious nuisance value. However, ignorance and unpreparedness which conduce to panic can make possible much more serious effects.

Internal Hazards from Radioactive Isotopes

This consideration of internal hazards brings us to the matter of radioactive isotopes. The clinical and experimental use of radioactive isotopes will be discussed later, so that we will take up here the matter of the long-lived radioactive isotopes apt to reach internal structures. In the past the radium group was the only one apt to figure extensively in this matter. Now there is plutonium as well, and we need to remember that long-lived fission products such as Sr^{89} and Sr^{90}, C^{14}, Cs^{135} and Cs^{137}, Sb^{125} and Ce^{144} will be involved. For example, Sr^{90}, a Beta emitter, shows a 25 year half-life period, is well absorbed, seeks bony structures and requires over 200 days for elimination. It thus has disagreeable possibilities. $Cerium^{144}$ (275 days) can cause liver atrophy as well as bone sarcoma. Plutonium, itself an alpha emitter, is a bone seeker and is pre-eminently apt to produce blood changes and bone sarcoma; animal experiments indicate that it can also cause liver damage, graying of hair and tumors at any point of lodgment. Po^{210} may affect the kidneys upon excretion.

Pathologic effects depend largely upon where the material localizes. The main danger from radium derives from the fact that it is a bone seeker and alpha emitter. In spite of short range, alpha particles are extremely potent ionizers and thus damage both bone and embryonal blood cells, so favoring aplastic anemia, leukopenia, thrombocytopenia and tumor formation. Dust conveying radioactive contamination will also naturally produce radioactive deposits in the lungs and favor tumors. It has been known for centuries that miners working in the old mines at Joachimsthal in Bohemia and

Sneeberg in Sacony often died of lung complaints. Lately, it has been found that much of this is attributable to cancer from radioactive material (uranium ores) - the rates of incidence being 22 as against 1.5 for the general population.

The case of the radium dial workers is one well known and famous in medical annals. A good account is given by Martland in the Journal of the American Medical Association, viz., "Occupational Poisoning," Vol. 92, #6 and #7, pages 466 and 552, February 1929. It is worth looking up when you find yourself with a little leisure while in a medical library. What happened was that a number of these workers absorbed radium or mesothorium with the result that there were a number of deaths from things as anemia, buccal necroses and sarcoma of the bones. These were finally traced to the radioactive material they ingested.

Practical Considerations and Dosage Levels

Our main considerations are related to large scale handling of radioactive materials in connection with military, medical and industrial uses. A primary and difficult matter is the inhalation problem. There lies perhaps the most insidious hazard. Plutonium is an alpha emitter and there can be no doubt that it will in any notable amounts, which in this instance is in terms of microcuries, be carcinogenic. Further, when it reaches the circulation, it seeks the endosteal spaces and so has the ability to produce anemias, and blood dyscrasias just as radium. It is greatly to the credit of those responsible for radiation safety and health measures

in our gigantic plants that we are not headed for any such disasters that overtook workers of no more than 20 years ago. This is the result of high safety standards and low levels of permissible dosage.

As regards tolerance or permissible amounts, neither plutonium or radium can be called tolerable at all but standards are devised with the idea of keeping lifetime absorption below 1 microgram. A safe limit is mentioned by Parker as 0.1 of this in view of an equivalence in REM's in the bony structures calculated at .160 REP per day. Since definite damage has been related to a single microgram in some experimental work, this margin of safety is hardly excessive. It might be noted that the fatal cases reported by Martland showed from 14 to 180 micrograms in the bony structures. It is worthy of note too, that Plutonium, although it disintegrates more slowly than Radium (half life of about 25,000 instead of about 1600), is given the same tolerance figure. This is because histologically it settles in the endosteal spaces so that a greater percentage of its alpha particles will reach blood-forming cells than is the case with Radium which is more widely diffused in the bone. Pu is also eliminated much more slowly than Ra.

Ingestion hazards from Pu are not of the same degree as with Ra since efficiency of absorption is low. Nevertheless, one cannot rely on such too implicitly and we have to think of the local effects of the gastro-intestinal tract and its lymph glands which could well retain Pu particles. Thus, ~~so~~ rigid safeguards are in order. Inhalation is a much more serious matter and so we have the usual "housekeeping"

safeguards to keep dust contamination at a minimum and monitor the air in working spaces, also surfaces suspected of contamination by the alpha emitters. Permissible concentration of radioactivity is set at 5×10^{10} micrograms or 3×10^{-11} microcuries per cc. When there is possibility of dust hazards, protective masks are in order.

Permissible Dosage Table

Basic unit, the r or Roentgen, originally applied to x and gamma rays. It produces 1 esu of charge in 1 cc or 0.001293 gm air. The r is equivalent in energy to an 93 ergs per gram average for tissue and results in 1.615×10^{12} ion pairs per gram tissue.

Derivative units: Roentgen equivalent physical or REP based on the energy production noted above, and roentgen equivalent man or REM based on equivalence of biological effects.

Basic permissible dosage 0.3 r/week.*

In detail this works out as follows:

EXTERNAL RADIATION

(1) Total body exposure	0.3 r (0.3 REP) integrated over a period of a week obtained in a single or accumulated dose. 0.05 r (0.05 REP) or less/24 hours for routine operations. Integrated exposures greater than 0.3 r per week require removal from further exposure until "recovery" can be effected using one week as the time index of exposure.
(2) Local external	1.0 r/week for beta exposure to the hands.
(3) Individuals working with external radiation for short period not to exceed two years.	1.25 r/month - single exposure allowable if no further exposure that month.

* Will probably be increased to 0.6 r/wk for those over 45.

(4) Particle accelerators and neutron exposures.	Special tolerance consideration not in scope of publication.

INTERNAL RADIATION

(1) Plutonium or heavy alpha emitters.	5×10^{-12} microcuries/cc of air for continuous exposure for one year.
Plutonium	0.5 microgram within the body.
Radium	0.1 microgram within the body,
Radon	10^{-12} curie/liter exhaled air. 5×10^{-13} curie/liter exhaled air. (pre-employment)
(2) Air contamination by more hazardous beta/gamma emitters.	10^{-9} microcuries/cc air. General rule is to wear masks when content exceeds 10^{-9} microcuries/cc air and to evacuate area where air content exceeds 10^{-8} microcuries per cc air.
(3) Air contamination-alpha. Radon	5×10^{-12} microcuries/cc air. 10^{-11} curies/litter.
(4) Food and water contamination.	10^{-7} microcuries/cc.

Radioactive Substances

Basic unit, the curie or radioactivity equal to that from the radon in equilibrium with 1 gram of its parent substance, radium. (Requires 132 days to establish).

Millicurie 1/1000th curie
Microcurie 1/1000th millicurie
1 curie equivalent to 3.7×10^{10} disintegrations/sec.
1 millicurie equivalent to 3.7×10^{7} disintegrations/sec.

Roentgen Hour Meter (RHM) (proposed) degree of radioactivity that will produce 1 r/hr at 1 meter; requires 1.16 gm radium; relates largely to gamma and alpha emitters in general.

R equivalents of curies: Varies greatly depending upon type and energy of radiations as well as distance and filtration factors which greatly affect alpha and beta:

1 gm or 1 curie Ra: 480 r/sec at 1 cm mostly from alpha (2.4 r from gamma)
0.864 r per hour at 1 meter (gamma)
R value of Ra with 1/2 mm Pt filtration (gamma rays only)

$$r/h = \frac{8.4 \times mgm}{cm^2}$$

Permissible Amounts and Concentrations of Radioisotopes that Become Fixed in the Body

Element	Maximum Permissible Amount in Body	Maximum Permissible Concentration Air	Maximum Permissible Concentration Water
C^{14}	10^3 μc	$1x10^{-6}$ μc/cc	10^{-2} μc/cc
Na^{24}	15 μc	10^{-6} μc/cc	0.005 μc/cc
P^{32}	10 μc	$2x10^{-8}$ μc/cc	$2x10^{-4}$ μc/cc
I^{131}	0.1 μc	10^{-9} μc/cc	10^{-5} μc/cc
U	---	50 μg/m^3	---
		$3.3x10^{-11}$	
Ra^{226}	0.1 μgm	$2x10^{-12}$ μc/cc	$4x10^{-8}$ μc/cc
Pu(soluble)	---	1 $\cancel{5}x10^{-12}$ μgm/cc	$4x10^{-6}$ μgm/cc
Pu(insoluble)	---	2 $2.5x10^{-11}$ μgm/cc	---

All the values are to be divided by an additional factor of safety of 100 when they are applied to large centers of population.

CONCLUDING REMARKS. As mentioned already, the upper limit of cumulative dosage is a matter of much concern on the score of individual welfare and welfare of the race. We need increasingly

precise information which, however, may be a long time coming. In the meantime, it is certain we should minimize exposure and correct natural tendencies to forget and even circumvent safety rules.

In every day clinical medicine we have radiography and therapy to consider in relation to the patient and doctors and technicians. Standard safety practices have been in effect many years and in general, patients are well protected. However, the future will probably bring an increasing degree of exposure rather than the opposite and there are inspectoscopes and wider application of photofluoroscopy in the offing. It is probable that technicians and radiologists could profitably go in for dosimetry to keep track of their accumulated ~~experience~~ exposure. This would discourage recklessness, reveal shortcomings, promote caution, and give excellent training. As a matter of fact, such a program is in effect in the Navy at present.

As regards patients, although it would be difficult and uncertain to relate casual radiographic exposure to terms at all equivalent to total body irradiation, nevertheless certain types who require repeated radiography, e.g. chronic urologic and gastro-intestinal cases, deserve special records and special thought. Prepartum films may be brought into question and recent studies indicate a probability of about 0.9 r in the pelvis from a set of radiographs. This does not appear too serious, but on the other hand, one should certainly not be free with repeats. Inspectoscopes (anti-theft and anti-sabotage fluoroscopy) demands stringent oversight.

A final word as regards isotopes. There is great enthusiasm for them ~~at present~~ and certainly use of them is increasing rapidly. We have seen how enthusiasm has blunted the edge of risk perception in the past and we must remeber that all precautions are still in order and that we must be on guard constantly.

For radiological safety in this age and time we need a combination of:

Carefully drawn up rules.
Properly safeguarded apparatus
Sound methods
Properly indoctrinated personnel
High standards
Good supervision and vigilant inspection
High morale and cooperation

Finally, the basic principle must be never to accept excess exposures except under the most compelling and unavoidable circumstances. This takes time, effort, thought, painstaking care, and expense, but we have no real choice but to carry on at this level.

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Medical Problems of Atomic Defense

First of all let me express my appreciation to Admiral Bolster and Captain Shilling of O.N.R. for the opportunity to give this talk to you. I appreciate being here for several reasons: I am glad to present information about a subject of such importance; then from a selfish standpoint, I am always glad to revisit Bethesda where I spent so many pleasant years in active professional work and where later I was privileged to be associated both with the Atomic Defense Division and the Research Institute. Finally, I am glad to see so many scientists whose interest in the Navy has kept them active in the reserve.

It is very encouraging - all the more so since many people take a dubious view of people in uniform doing research and high grade technical work. The fact is, of course, that scientists in uniform have done and are doing important research, and I think we can look to the future with optimism. True there are handicaps but there are also advantages. In general from year to

year there is a trend to better accommodation for our researchers and skilled technicians.

~~Handicaps relate largely to rotation in assignment, interruption and interferences, bureaucratic budgeting and general inelasticity. Regarding the first, how is one to know the Navy intimately if he doesn't circulate around a bit? And I mean not only circulate but actually do duty in more than one place and occasionally at sea. Such intimacy with service life can serve to promote insight into naval problems and necessities and also stimulate new ideas.~~

~~The whole thing, of course, relates not merely to proper balance in naval experience but also consideration of all circumstances pertaining to the individual and the work he is doing.~~

At all events, I am here to say a few words on the medical aspects of atomic defense in the Navy and in so doing one immediately becomes concerned in research. That is natural because in spite of all the efforts made to date we have no end of things to learn yet.

One can only marvel at some of the stories that come up from the past relating to a feeling of hopelessness on the part of some people because everything worth while has been discovered or invented and there was nothing left to do.

We laugh, snicker or smile at such things yet let us remember that challenging phenomena often lie unperceived or neglected right under our own noses. Thus x-rays were almost begging for discovery while scientists like our own Dr. Goodspeed laid aside the puzzling clues ~~events~~ for another day. It remained for Roentgen to perceive that something really startling was happening in connection with Crooke's tubes and then to go after it systematically and brilliantly.

The result is familiar history and there is no point in further detail other than to pay tribute in passing to Wilhelm Conrad Roentgen as a great scientist and a great man. He is, one might say, the patron saint of radiologists and a most worthy one; and his work at the turn of the century startled the world almost as much as did the atomic bomb half a century later.

I mention this not merely because of similarity in sensational publicity but because in addition there is an interrelation. The study of ionizing radiation in the guise of ~~resulting from~~ x-ray soon progressed into the study of ionizing radiations emitted naturally from certain elements. Soon we had Becquerel's discovery of natural radioactivity and then the Curies' discovery of Radium and Polonium.

The story of how this led up to the discovery of fission possibilities and the invention of the A bomb is quite too long for this occasion. It is interesting though to reflect that a discovery with the most fearful potentialities began with very little fanfare when Hahn and Strassman dubiously noted that something very curious happened when they were trying to build up transuranic elements by shooting neutrons into uranium. They obtained traces of lighter elements such as Ba and Kr and it was evident that the heavy uranium atoms were breaking into lighter fragments.

To a handful of scientists this was of startling and tremenduous concern. To most of us the implication would not have been apparent and the discovery merely something to rouse idle speculation; and indeed the remarks of scientists about huge energy releases did result in some Sunday supplement articles about ships going round the world powered by a little uranium. However most of us put that idea in a category of very remote possibilities just as was done early in the century regarding the concluding remarks of the great British scientist Thompson in one of his books: "There is power enough in every breath we draw to run the workshops of the world." I remember quoting that in a thesis I prepared on "Radium and Radioactivity and the Disintegration of Matter" in 1915, almost 40 years ago, 37 to be precise. Well on this modern occasion the situation was radically different because the release of neutrons upon fissioning of uranium indicated the possibility of a chain reaction. I need not go into that subject further with this audience but would only note

22 July

Begin

Early in the century the

that most of us would be about as obtuse in recognizing that as important news as the old darky of Nat Wills' famous recitation "No News or What Killed the Dog". This amused people a generation ago and is now so old that it can be revived once in a while in the knowledge that very few remember the skit.

At all events fission, the chain reaction with fantastic energy release and the various ramifications into nucleonics and radioactive isotopes have brought us into the modern Atomic Age.

Thanks to the war the gestation was not only accelerated but the birth dramatic and horrible in the extreme.

With the blinding flash and thundering roar of a gigantic explosion, Hiroshima crumbled in ruins which in a short time were swept by a fire storm.

A few days later it was repeated for Nagasaki except for the fire storm.

Such are the possibilities we have to live with in this age and hateful as the prospect is, we must face it. We may find ourselves on the receiving end of similar bombs. Wherefore the great and necessary emphasis these days on civil defense as well as the concern of the military for both offense and defense.

The medical problems relate largely to defense and it is with these ~~problem~~ that I would like to deal briefly.

The medical problems of Atomic Defense are enormous and the Navy Medical Department comes in for an extra share of them. We have certain peculiar naval features to deal with and in addition are concerned with most other problems as well. The Navy Medical Department is the one that functions all over; over the seas in our various types of naval vessels; under the sea in submarines; in the air with planes and blimps, and ashore or amphibiously with the marines. And since many of our naval hospitals are in or near

important cities, we become concerned with emergency aid in assaults upon cities. Finally we now have some special problems with our nuclear powered submarine.

The problems of atomic and other special weapons are such that we habitually devote a full week to skim the field in our courses for reserve medical officers. Thus, if this dissertation is somewhat fragmentary or rudimentary I hope you will be lenient in judgment.

As you may recollect the Navy first became seriously involved with atomic weapons in the conduct of Operation Crossroads. Those tests called for extensive research and following the underwater burst of Test Baker, very troublesome radiological safety problems had to be met.

The advent of nuclear weapons had already caused much cogitation and the realization that the future would bring more and more problems resulted in the establishment of the AFSWP for general coordination of A.W. matters in all services. Within the

Navy Medical Department the Atomic Defense Division was set up in 1947 and now is part of the "Special Weapons Division." The responsibilities of the division relate largely to Radiological Safety, Training, Research and Classified files.

In connection with the first, suitable standards were set up and promulgated. Eventually they were codified in a formal brochure and a recent revision is now available.

It was early recognized that personnel dosimetry was an important consideration for the Navy - the reason being that we are more likely to be concerned with subsurface (underwater) burst, than any other organization.

Such burst, of course, produce gross radioactive contamination on a large scale. In connection therewith we have to think of such things as

(a) Escape and rescue operations

(b) Decontamination of personnel involved in base surge or "fall out" and provisions for casualties.

(c) Essential naval operations in the midst of contamination.

(d) Decontamination of material.

The evaluation of risks thus incurred bring up the matter of personnel monitoring and what we call calculated risk in accepting exposure.

At present the most generally practical, accurate and economical method is photodosimetry. The Radiological Safety branch promptly went to work on the service problems concerned with this procedure and after several years of preparatory effort it became possible to adopt the procedure throughout the naval service in our hospitals and also industrial radiological departments. This serves the double purpose of providing a greater measure of radiological safety and developing a group of trained personnel for military needs in the event of atomic warfare.

Before leaving the matter of radiological safety it should be noted that there is still considerable confusion about two

aspects. (1) The over-all importance of radiological hazards. (2) Appropriate standards for the Calculated Risk type of exposure hazard just mentioned.

Following the Japanese bombings, severe radiation illness as a formidable, unfamiliar, devastating and frequently fatal complication, made its bow to the world in gruesome fashion which could have provided worthy inspiration for Dante or our own Poe.

It was novel, startling and disconcerting; and the very natural concern over this type of casualty soon ballooned into disproportionate preoccupation so that many people were thinking in terms of Geiger counters when they should have been thinking primarily of the more customary varieties of injury. It became necessary to point out that this loss of perspective could lead to misdirection of effort and predisposition to disastrous panic.

The fact is that with an air burst, which is the most likely form of attack, the best estimates give us only 15% of casualties from radiation. That I think can speak for itself

as indicating that it is not the major hazard. Burns, crushing injuries lacerations from shattered glass and trauma from flying or falling debris are the major injuries we will have to contend with. Nevertheless the radiation hazard is still a substantial one, and not to be disregarded either. The feature of immediate importance is that with an air burst radiation will have no important bearing on rescue operations, or first aid.

It will become more important later and it is well to remember also that other factors may enter the picture: First, burns and other trauma may be very adversely affected by very moderate dosage of radiation. Second, granted good civil defense with adequate warning is to be expected most people will reach shelters where they will be protected from flash burns and blast. This will greatly reduce casualties from those causes. At the same time many shelters will not protect sufficiently from γ rays & neutrons so that we may have an increase in radiation illness beyond what is currently anticipated.

Finally, although unlikely as a major method of assualt, RW might be employed as a panic weapon and we should be prepared to deal with it.

Thus in avoiding overconcern about radiation we must not run into the opposite danger of disregarding it.

Reverting now to the confusion concerning calculated risk:

It is generally known that the standard permissible dosage limit is 0.3 r/wk. This was adopted quite recently, the limit previously being 0.1 r/d. This is very low and quite rightly so for it is designed to protect workers constantly subjected to exposure in the course of their occupation. However, this background tends to be forgotten and when there is talk of exposures of 10-25-50 and 100 r or more, people become greatly concerned or even panicy.

It is well to remember that the 0.3 r standard has only indirect relation to occasional exposures.

It is common to grossly exceed this level in everyday practice of clinical radiology and we consider practical factors of necessity and not 0.3 r/wk.

Similarly in the matter of Atomic Defense we must be just as practical in the matter of occasional exposures. Let us note some quantitative relations from NEPA Medical Advisory Panel report 1019-IER-17 compiled 1949

ACUTE */ EXPOSURE Estimated Results to Humans Exposed to Filtered 200-100 KVP x-rays, Measured in Air.

The estimates given below apply to the average normal individual. It should be borne in mind that there is considerable variations in individuals' susceptibility to radiation.

A. 25 r and below; no detectable clinical effects.

1. From animal experiments it would appear that if man behaves like the mouse and drosophila, there will be, due to radiation, a genetic effect which is much smaller than the spontaneous rate of mutations. In other words, the combined result of the spontaneous and the radiation-induced genetic abnormalities would be slightly increased but much less than double the spontaneous rate alone.

2. Delayed effects **/ possible but highly improbable.

---

*/ Received within twenty-four hours.

**/ The expression, "delayed effects", as used here, referes to any harmful effects attributable to radiation on the recipient of the radiation and manifested at any time subsequent to the period when acute reactions may occur.

Ev...

Power possibilities
envisioned early in century
Arthur J Thompson
~~Henry Adams~~
Einstein
Few had any inkling
of ~~that~~ the more really
possibilities. Only here & there
some took it serious ~~th~~
~~number small beyond that~~
~~of the often quoted line of Virgil~~
~~Apparent rari nantes~~
~~in gurgite vasto~~

And of all people the dry ~~& somewhat~~ sedate & somewhat waspish historian Henry Adams was one to point to the future - predicting revolutionary theory - got part

My own introduction to the which began with Thompson's book & some startling & beautiful demonstrations in our high school along about 1912. Not demonstrations of atoms, for to be sure but electrical experiments to indicate something of the nature of atoms. ~~The~~ Our professor of astronomy told ~~us that~~ believed at that time that the energy of sun was derived from the phenomenon related to radioactivity: I remember writing my college thesis on physics was about Rad. Radium & the disintegration of matter

Well in spite of all the ~~[illegible]~~ speculation & hopes subsided for a time because it turned out the radioactive elements were very stubborn. They decayed to suit themselves. ~~& we [illegible] the [illegible] [illegible] [illegible] [illegible] [illegible]~~ & we could not change the rate no more than the unfortunate chap in Balzac's onager ~~famous~~ story could stretch the magic skin.

The energy was there but how
tap it? ~~The~~
The key to that riddle was
found by Hahn & Strassman

B. 50 r; slight transient reductions in lymphocytes and neutrophiles. No other clinically detectable effects.

1. Incidence of radiation-induced genetic abnormalities is expected to be approximately the same or smaller than the spontaneously occurring abnormalities.
2. Delayed effects possible but serious effects on the average individual very improbable.

C. 100 r; at this level, nausea and fatigue may be a problem. Reductions in lymphocytes and neutrophiles with delayed recovery. Above 125-150 r, vomiting may become a problem.

1. Incidence of radiation-induced genetic abnormalities, which are quantitatively proportional to the dose, will probably still be comparable to or somewhat greater than those occurring spontaneously.
2. Delayed effects, in summation, would be expected to shorten the life expectancy of man on the average by not more than about 1% from all causes, assuming that limited observations on animals can be extrapolated to man.

D. 200 r; at this level fatalities, 2-6 weeks after exposures, might occur in a small proportion of the irradiated individuals. Nausea, vomiting and fatigue will probably occur in most persons within 24 hours. Definite depression of practically all blood elements, reduced vitality, in most cases with a convalescent period of 3 to 6 months. Temporary sterility in some cases and possibly permanent sterility in rare instances.

1. Incidence of radiation-induced genetic abnormalities will be expected to be at least twice as frequent as the spontaneously occurring abnormalities.

2. Delayed effects - that these would be of major consequence in a small percentage of individuals would seem very probable.

E. <u>400 r</u>; it would be expected that virtually everyone would be immediately incapacitated by such an amount of radiation, and many would never recover completely. Some deaths would occur in 2 to 6 weeks.

One can add to this tabulation that 400 r is probably in the LD50 zone, i.e. the zone in which 50% of fatalities is likely.

One can also add that 600 r would almost invariably prove fatal.

So much for acute exposures. It is conjecturable that certain operations such as nuclear propulsion of air craft might entail repeated exposures of moderate degree. In this regard current thought is that exposures up to about 25 r might be repeated weekly to a total of 200 r with relative impunity.

The word "relative" is used advisedly because it might be remembered that often ionizing radiation is a noxious agent reminiscent in its effects of a general protoplasmic poison.

Therefore we must always aim to reduce exposure to a minimum and never accept "calculated risk" degrees of exposure lightly.

* * * *

The training activities have been very widespread and have involved short courses, intermediate and some up to several years. The Medical School in cooperation with the Atomic Defense Division set up short courses some three years ago. They are still continued and are quite popular, being well attended largely by Reserve M.O.S. Members of the staff of the Atomic Defense Division and of the Naval Medical Center, particularly NMRI, have given generously of their time and effort in connection with these courses in special weapons, and also in giving lectures all over the country and indeed the world. It should be noted too that we have made use of many experts from civil life to help in these courses. (Drs. Lapp, Carl Z. Morgan, Shields Warren, Charles Geschickter, Gemil, Gerstell, George Lyon, and others have all helped.)

It might be noted too that one of the earliest and most useful brochures on the medical aspects of A.W. was prepared in the Atomic Defense Division largely by Captain Haight.

Post graduate training has been carried out in various universities and has usually been supplemented by three months indoctrination at Oak Ridge.

Finally, before leaving the matter of training it should be noted that at the Naval Medical School, all x-ray technicians are trained in photodosimetry and selected ones in isotope technique.

* * * *

Coming to the matter of research, the Navy Medical Department covers a very wide range in the matter of A.W.

A considerable amount of research is vigorously pursued at NMRI and NRDL, and there is active participation in the field of atomic weapons. In fact NMRI has had to "carry the ball" in many operational and organizational phases of the biomedical

programs of these tests. Outside the Navy, through ONR many university projects are being supported by the Navy.

Time would not permit and it would also prove tiresome to catalog completely what we are doing study by study. Instead I will only touch on some of the high lights.

At Operation Crossroads much general information was obtained which helped a lot to firm up effects of total body irradiation. In succeeding tests the effort was made to obtain more detailed and precise information as burns and radiation in particular. Elaborate devices were designed, constructed and tested to that end and I might say that an enormous amount of study and work went into those efforts. That was essential in order to obtain valid results under very difficult operational circumstances. Captain Draeger and the Institute staff were especially active in this matter and did the lion's share of developmental work.

Pathology, and hematology of radiation illness were studied in great detail and surviving mice are being followed up

indefinitely for remote effects. A major effort was made in the study of burn phenomenology by Dr. Pearce of Rochester, New York and his group.

On the radiation physics side, radiological phantoms were used to determine more precisely the energy spectrum of the ionizing radiation. (Describe phantoms) That is very important from the standpoint of protection.

We have also been interested in personnel dosimetry beyond the ordinary working levels. Work on activated Bromide crystals has been done at the Institute and this has resulted in a device in which simple color change to varying degrees of blue gives a good estimate of exposure beyond 25 r.

Work at NRDL has produced a phosphor glass which gives satisfactory readings beyond 10 r this by vitue of proportionate fluorescence under U.V. It is not self reading but is cheap and practicable and widespread use in the Navy is anticipated.

At NRDL there have been studies of performance following exposure to radiation. It is well known that serious exposures

reduce performance levels and increase vulnerability to stress. What we desire in that field is more precision and it is hoped some interesting results will be forthcoming. They are also engaged in a number of interesting biological studies of fundamental nature and considerable work is being done on decontamination problems.

At NMRI we have done much work following up the field tests. Numerous pathological studies have been made and many studies on hematological problems.

Studies on glutathione and other prospective or possible remedies have been made.

One of the difficulties in radiation work on experimental animals has been comparison and reduplication of results. This has been given great attention by Dr. Ellinger, CDR Chambers and CDR Morgan. It was found possible to stabilize the physical factors much more closely by regulation of current fluctuations and careful dosimetry and to apply more precise exposure techniques.

The results were so encouraging that an exhibit was made for the last meeting of the Radiological Society of North America and is being shown again, I believe at the American Medical Association.

Some of the things we have been doing here are: Studies on radioactive Gallium in relation to diagnostic and therapeutic possibilities and studies involving staining techniques; I have skipped along very rapidly in this -- all the more so that you will be able to see for yourself what our people are doing in the laboratories. I hope to rouse more curiousity than satisfy it.

Finally, I might note that in order to cover the energy range of radiation with some completeness we have nearly finished installation of a Van de Graaf generator - 2 mev (this will be used cooperatively with the naval hospital) and also the installation of a specially designed γ ray generator employing Cobalt 60. This is the most interesting piece of apparatus which I hope you will all take a look at.

Much work has been done on blast generator designs and prototypes to duplicate the shock wave form of an Atomic Explosion.

We hope that interesting studies will be forthcoming from this effort eventually. There have been lots of difficulties and delays in developing a type sufficiently large.

ONR should not be passed by and it should be noted that the Navy is sponsoring extensive research in the field of A.W. This relates to trauma in general, shock and thermal injuries as well as ionizing radiation.

So much for this very general and superficial resume of research. As presented, it doesn't signify very much other than that we are very active. As a matter of fact all listings and descriptions pertaining to research are insufficiently revealing. You need to see the work going on, talk to investigators, and finally see results and reports. These I am glad you will have the opportunity to do in part and I am sure the Research Institute and its staff will provide much to interest you.

In closing I would like to describe briefly general orientation in the field of A.W. research. Naturally it involves

the answers to what we don't know or know with too little preciseness.

First of all we wish to know much more about all the fundamental effects of radiation on protoplasm, tissues, organs, and circulation.

(2) We wish more precise knowledge as to long range effects of radiation on the individual and on the race particularly as related to standards for permissible exposure levels and prognosis.

(3) We need still more information on the matter of internal radiation hazards from various radioactive isotopes and associated therewith, contamination and decontamination problems.

(4) We need more information as already indicated on performance and effort possibilities associated with heavy exposures.

(5) We wish to explore further the therapeutic possibilities in radiation diseases. We are far from satisfied with what we can do and there is a long way to go.

(6) We need more data on plasma extenders. We must reckon with the possibility that a major assault on the country would entail casualties on the scale of millions and far exceeding our ability to supply the whole blood and plasma desired.

(7) We are interested in further improvement in methods of parenteral nutrition.

(8) We need more work on tissue preservation involving bone, skin and blood vessel banks.

As a final note in the matter of atomic warfare I might mention Civil Defense. Naturally that is not supposed to be a service concern; it has its own establishment and a very large one. Nevertheless there are broad fields for cooperation between service and civilian defense organizations. We will all of us be battling with huge problems and will have to aid each other if the gage of major warfare is flung into our face.

Certainly the service hospitals and medical departments in general are going to be called on. Aside from that a direct naval

concern is that a number of our great shipyards are in likely target areas - New York, Philadelphia, Boston and San Francisco.

The Navy and Air Force too, have special responsibilities in interception, warning and communications.

The Army and Marines may well be called on for various emergency services. It is not contemplated and should not be, that the services will "run" civil defense. It is well recognized that they have other concerns. Nevertheless some emergency help is likely to be inevitable and in order that this will not become excessive or by default extend too much or too long into control phases an efficient, capable, and adequate civil defense is of direct concern to the services. So much is this so that the services have gone along with FCDA and FSRB in a large research project designed to make a complete and comprehensive survey of all the aspects and problems of civil defense. This has been a large order and was undertaken by the A.U.I. (the organization that operates Brookhaven) under the title "Project East River".

The work is now nearing completion and it is expected that reports will be published in the late summer.

I believe it will furnish an excellent and comprehensive background for CD planning. It will provide authoritative information and give a number of thoughtful recommendations, many of which in the nature of things, spell some trouble and expense. The effort is keyed, however, to the concept of what is reasonable and practicable rather than to offering perfectionist solutions.

For instance it is proper to talk of dispersal and it is certain much can be done on this score. Nevertheless a perfectionist type of calculation made some years ago produced a figure of $300 billion dollars in cost combined with ruinous economic disturbance and interference with production. I recall General Graves mentioning that figure in 1947. It is doubtless reasonably correct but the reaction to such figures is that many say in effect "It's absurd to even think about" and so the whole subject is dropped or given scant attention. We tend to extremes and so if we can't do everything desirable we are apt to sit back and do nothing.

At any rate this Project East River has called for much work by many able people and it is not too much to hope that its findings will be given earnest and continued consideration by all people in responsible positions.

As noted before we in the military are vitally concerned and it can be pointed out that not only will a good civil defense keep us going by preventing or minimizing loss of the sinews of war, but will tend to prevent all out war. It is well recognized by enemies that our industrial might and the scientific and technical knowledge of our people, as well as the valor and skill of our fighting men turned the tide of victory in our favor in two major wars. Thus one of the first purposes of an enemy would be to knock out our industry and if a well organized civil defense is added to good military preparedness any enemy will hesitate very long before he plays the final card of all-out combat.

The part that all of us in research can play in the matter is obvious. It is essential that our country be in the vanguard

of scientific progress in both basic and developmental research. We need plenty of both and they really go hand in hand. And if we maintain an open mind, alert curiosity, willingness to explore new possibilities we can be sure that there will be great rewards not only from the standpoint of national defense but from the standpoint of the healthier and happier living.

ADVANCES IN RADIO-
ISOTOPE THERAPY - Miami

23 October 1952

Dear Mr. Browdy:

Thank you for the clearance. I am enclosing a copy for your files. A few changes have been made but they do not affect clearance. Recent articles and the meeting of the Cancer Society here gave me a few more points to incorporate.

Hope all is well with you.

Best regards.

Sincerely yours,

C. F. BEHRENS
Rear Admiral, MC, USN

LCDR H. Browdy, MSC, USN
Technical Information Officer
Bureau of Medicine and Surgery
Department of the Navy
Washington 25, D.C.

DEPARTMENT OF THE NAVY
BUREAU OF MEDICINE AND SURGERY
WASHINGTON 25, D. C.

IN REPLY REFER TO
13:HB:arl
21 Oct 1952

Rear Admiral C. F. Behrens, MC, USN
Headquarters Eastern Sea Frontier
90 Church Street
New York, N. Y.

Dear Admiral Behrens:

I am returning herewith a cleared stamped copy of your article entitled, "Recent Advances in Radioisotope Therapy". Of the two copies which you forwarded to me, one copy is being retained on file in Security Review Section, Office of Public Information, Department of Defense, and the other is the enclosure.

I would greatly appreciate receiving a copy of this article, if available, to be placed in the files of our office.

If we can be of any further assistance to you at any time, please do not hesitate to call on us.

Best wishes and kind regards.

Sincerely yours,

H. Browdy
H. BROWDY
Lieutenant Commander, MSC, USN
Technical Information Officer

RECENT ADVANCES IN RADIOISOTOPE THERAPY

It is a welcome novelty to speak of therapeutic advances in the ~~filed~~ field of radioactive isotopes. My usual task in the past five years has been to think and talk about atomic bombs. Thus I begin to find myself like a peculiar character in one of Charles Dickens' novels. This poor fellow was writing or attempting to write a history of England - but could never get beyond the head of Charles I - that unhappy monarch who was beheaded by his bold and ruthless opponent, Oliver Cromwell.

Preoccupation with nuclear weapons is, of course, my own particular handicap and I hope it is not too severe a one.

So then, dodging the bomb on this occasion let us survey what goes on with the isotope families, with particular reference to what is new.

We are always interested in news, particularly as physicians, when it has practical bearing on therapy. I am afraid though that such is the promptness of modern publicity that you probably know all the news about my subject as well if not better than I. Thus perhaps I will be bringing you more of an evaluation than anything.

Presentation at the Southern Medical Association, Miami, Florida, 10-11 November 1952.

D-5164

At all events when we speak of isotopes in these present times we have in mind radioactive isotopes and likely enough many people associate magic possibilities with them. Surely term isotope is now one to conjure with: It is no longer a recondite term employed by chemists and physicists for their own obscure purposes and perhaps to plague any mystify their hapless students. Now it may savour of the sacrilegious to speak of magic possibilities to a scientific minded medical audience. But all of us, scientists or not, sometimes over-induldge in extravagant hopes and in all truth such extravagant things have happened in the past decade that we can all be pardoned for becoming a little dizzy in the head and expecting most anything including a little dash of magic. Well perhaps we have that too because our physicists have outstripped descriptions and imaginative visualizations. Things happen in amazing and peculiar ways and we learn of physical laws never dreamed of before and at time transcending the power of human description or comprehension.

It seems that much of this newer physics relates to radiation, isotopes and transmutation of elements. The story began or rather emerged from the laboratories very spectacularily with Roentgens discovery of the x-ray followed by Becquerel's discovery of natural radioactivity and very soon the isolation of Radium and Polonium by the Curies. And I might add that all

this caused very nearly as much astonishment, bewilderment and sensationalism as the atomic bomb in our own times.

The study of radium and related elements made us acquainted with new and mysterious radiations and taught us that certain elements were going through progressive transmutations eventually reverting to Pb. We also learned that enormous energy was being released.

Medically the doors opened to x-ray and radium therapy which we have all grown up with.

The modern efflorescence of interest and concern might be said to stem from the discovery of fission uranium by Hahn and Strassmann in 1939. That discovery led to the successful construction of uranium piles and the various other types of nuclear reactors and the atomic bomb.

Our chief therapeutic interest in all this, aside from the matter of atomic bomb casualties, lies in the fact that neutron fluxes of the nuclear reactors have made it possible to produce desirable radioisotopes in large quantities.

Coming to the medical and biological application of radioactive isotopes we find that such employment takes two main directions. First, there is the application to patients for therapeutic and diagnostic purposes. Then there is use in

research, often by tracer methodology. In addition and as a sort of adjunct to radiation safety and practical applications, there are numerous studies involving the toxicity and metabolism of the isotopes themselves. Considering the first, it is natural to entertain the hope that perhaps an isotope may be found that will act as the magic weapon with which to conquer cancer completely, once and for all. Such, however, has not been found and it may well be that this complete measure of success will continue to elude us. There are several inherent difficulties. These are related to a sufficient degree of selective absorption of the particular elements concerned, convenient and effective types of radiation, suitable half life and relative freedom from toxic effects.

Therapeutic and diagnostic uses are of course most interesting and often spectacular, but it is quite likely that the more slow and toilsome application of radioactive isotopes to biological research will yield long range benefits of even greater importance. The ability to trace important elements and the chemical molecules or radicals to which they are attached is naturally a great asset, and that is what the use of radioactive isotopes as tracers makes possible. Eventually we may be able to unravel the metabolic aberrations responsible for the uncontrolled growth of malignant tumor cells; and that may open the door to a basic attack upon neoplastic disease.

Methods of application include rate of appearance and disappearance of the radioactive elements along with quantitative

radiation studies of tissue, tissue fluids and excretory products. In addition radioautography is extensively employed and it is often of great value to use radioactive tracers in partition chromatography.

General difficulties arise from the lack of isotopes with characteristics we would like. Oxygen, nitrogen, and magnesium lack isotopes with useful half life. P_{32} although very useful, is a soft B emitter and so is often difficult to trace in vivo. C_{11} has such a short life that we can only use it right beside its place of origin. S35 is a soft B emitter too; likewise Fe55. C14 is not only a soft B emitter but lasts too long for comfort - over 6000 year half life.

There are also the matters of dosimety and radiological safety. These are becoming better known and standardized. Certain commercial concerns can or will be able to supply well standardized preparations. This will be very helpful, but yet, special skills, techniques and consultations will continue to be requisite and radiologists should acquire at least a good general background in the problems involved so as to help meet them to the best interest of all concerned.

Regardless of calibrations furnished with radioisotopes it is essential that activity be carefully measured before use. In the past as reported by Dr. Eugene Pendergrass radon tubes have shown gross discrepancies. There is no reason to suppose that error may not occur with other radioactive material.

in administration. There is only one point I would make here, other than the routine one of studying carefully the particular situations involved in a given installation. That point is:

Those concerned in actual handling of isotopes must practice well and learn thoroughly the techniques involved (remote controls - special pipets, working by mirror images, etc. so as to spare exposure both of general type and of fingers and hands.

Among the problems related to isotopes an important and recurring one is the matter of decision whether or not to use a given isotope in a given case. We now have a virtual embarrassment of riches as to methods of attack against certain illnesses.

Thus in hyperthyroidism there is surgery, x-ray, I^{131}, and thiouracil. In leucemias we have often to decide between x-ray and P32 and now possibly Au198. There is also nitrogen mustard to consider. What it boils down to is careful study of cases, consultation and preferably presentation before tumor boards or clinical conferences for discussion and aid in final decision.

A brief general summary such as this can hardly go beyond a few general observations as to factors we should take into account; and among these we should consider not only what seems theoretically best but what modality the staff concerned has the most experience with and greatest skill. Let us first consider Radioiodine (131); 8d; β 0.32, 0.6; γ 0.08-0.73.

The advisability of surgery in hyperthyroidism is traditionally related to the age and condition of the patient.

In this regard it can be pointed out that there is now less call than ever for taking chances on poor or dubious risks. X-ray versus radioiodine is still another problem. Both can control hyperthyroidism. X-ray involves a series of exposures, response is gradual and there may be irritation of the larynx, trachea and oesophagus. However, careful technique can avoid or minimize this. I^{131} is relatively easy on the patient but involves a lot of careful work by a skilled staff. It also involves some generalised exposure of the patient. This may be undesirable in reproductive years and particularly dangerous in early pregnancy. In connection with hyperthyroidism it might be noted that the uptake of I^{131} can serve as an accurate index probably comparable and possibly superior to the conventional BMR. This can be of much help in selected cases since it is not dependent on complete mental and physical relaxation of the patient. It is, of course, adversely affected by iodine, thyroid or antithyroid medication.

Thyroid carcinomas, of course, involve careful evaluation of the iodine uptake to determine whether a response is possible; and it is interesting to note that there is now evidence to suggest that promptly frozen biopsy material may prove suitable for preliminary study of this factor. (Am. J. Clin. Path., Sept 1951, W. N. Harsha and B. R. Harsha).

Dr. Beierwaltes of Ann Arbor has recently reviewed treatment of thyroid carcinoma with I^{131} in the Annals of

Internal Medicine (July 1952) and makes some useful points. He notes that 10 years have passed since the first case was treated with radioiodine. In the interval some 250 cases have been treated by this agent and out of the experience so gained, the role of I^{131} begins to clarify.

This role relates largely to combatting metastases thereby prolonging life and increasing comfort. There should first of all be total thyroidectomy radical neck dissection and unless extirpation appears certain, x-ray therapy. When metastases are detected they should be biopsied if possible. Follicular and alveolar types respond well, papillary types less; undifferentiated types are resistant.

As already noted the response is related to iodine uptake. This may be determined in various ways: (1) autoradiograph of a biopsy slice; (2) external counting; (3) amount of I^{131} recovered from urine (should be less than 30% in the first 48 to 96 hours); (4) blood level of I^{131}.

External counting is simplest and is frequently employed. Metastases near the surface showing an uptake count in 100 seconds 15 x that over a similar but unaffected anatomical area usually respond.

The urinary output often gives an accurate index subject to uncertainty as to the mass of the metastases.

In order to increase uptake by metastases the thyroidectomy is the most important factor. Thiouracil for several months after operation is mentioned as helpful if stopped two days before administration of the radioiodine. Thyrotropic hormone may also prove helpful. Iodide or thyroid medication interfere and mypedema is a contraindication. Naturally hypoplastic anemia makes radiation dangerous. In such cases I^{131} induce pancytopenia with danger of infection and hemorrhage.

Coming now to another familiar isotope we have P32; 14.3d; B^{-} 1.70.

In leucemias as already noted P32 has been found very useful. Nevertheless, in most cases of myelogenous leucemias and chronic lymphatic leucemias it is often possible to maintain long periods of palliation and ability to carry on routine affairs of life, easy and simply by x-ray. I would note too that very small doses to the splenic area will usually suffice in these cases and that with such small doses the incidence of radiation illness is seldom of serious concern. Some recent studies, however, suggest that combination of x-ray and P32 therapy may offer a longer life prospect.

Another prospect is that Au198 a B γ emitter may prove very helpful in leucemia. Following intravenous use it is picked up by the reticulo endothelial system and so the spleen receives a disproportionate amount of the radiation. It is susceptible of ambulatory administration and involves no radioactive excreta.

Hodgkin's disease presents a highly varied picture as related to rapidity of progress, degree of localization or, on the other hand, extent of spread, presence or not of bone lesions and responsiveness to therapy. Thus we have here a classic instance for nice judgment in each individual case. My own experience leans to x-ray but there are certainly cases for P32 and consideration of nitrogen mustard, particularly where the disease is widespread, resistant and accompanied by constitutional symptoms.

Polycythemia vera is coming to be treated more and more by P32. It is very effective in this disease and more convenient for the patient. X-ray is also very effective as most of us know, but it does call for an extensive and strenuous course.

Treatment is important and definitely prolongs life. It also calls for judgment. There are limits to the amount of radiation either from x-ray or isotopes, that can be given without great risk of pancytopenia and its accompanying hazards. Thus it seems well to withhold radiation as long as symptoms can be controlled by venesection. On the other hand waiting too long in the face of urgent symptoms will entail risk of thrombosis, cardiac failure and leucemia. It appears that on the whole the incidence of leucemia as a terminal complication of p.v. is lessened by radiation therapy. Yet there have been occasional instances of fulminating leucemia in courses of P32 therapy which may have been induced by the treatment.

Related to the particulate radiations of isotopes we have some new possibilities from apparatus. It is now possible to pull the electron beam from a betatron or synchotron and we will also be able to obtain beams of high energy from protons. Thus we may be able to do some effective therapy with these rays and study is in progress. With the electron beam, penetration and depth of densest ionisation increases with voltage and can thereby be regulated. At superficial and intermediate levels it lends itself to great concentration of effect with a rapid falling-off beyond those depths and consequent sparing of the deeper tissues. This factor promises to be of great benefit and early trials with energies up to 20-25 mev have turned out well. At high energy levels of 50-70 mev such as would be needed for deep lesions the rate of decrease becomes gradual and this particular benefit is lost.

Let's take a look now at some of the less familiar and more experimental radioisotopes.

One of these of considerable interest is Gallium 72. (14.08 h; B 0.6-3.2; γ 0.6-2.5). This element has been extensively studied by Drs. Dudley and King at Bethesda and later by Dr. Brucer and his associates at Oak Ridge. It is an energetic B γ emitter with a half life of 14.08 hours. Interest in it developed when it was found that it localized in areas of active bone formation. This suggested at once possible usefulness both in diagnosis and therapy. It is disappointing to record that the follow up of this promising lead indicates that limiting factors impose too great a handicap at the present time at least for adequate therapy. First of all Ga is

toxic in and of itself and unfortunately radiogallium as obtained is accompanied by a large amount of stable Ga. Thus it is not possible to attain an effective concentration for therapy. The second handicap is the short half life which obviously renders clinical work with it difficult.

However, if it ever become possible to obtain Ga72 sufficiently free of its stable isotope we may hear more favorable news. Further work is being considered including use of Ga67; 78 hr; γ 0.18; 0.3. 0.09; x-ray.

Cobalt 60: A fairly long half life of 5.26 years and the emission of 1.17 and 1.33 mev γ rays have made this isotope a valuable tool. A soft B of 0.32 mev is also emitted. Cobalt 60 is produced as most of you know by subjecting stable Cobalt to the neutron flux of a nuclear reactor.

The radiation is equivalent to that from the so-called supervoltage generators and is surpassed in energy only by betatrons and synchrotrons. Thus it was early realized that Co60 could serve as a source of therapeutic radiation.

Units of 1000 curie capacity have been constructed in Canada and produce 33 r/m at 80 cms. A report on the design and construction of a Cobalt teletherapy unit has been made by Grummett et all in the July 1952 number of Radiology (51 No. 1; 19-29).

A special type of Cobalt γ ray generator has been completed at the Naval Medical Research Institute under supervision of Captain R. H. Draeger. This is designed to permit of

diffuse total body radiation (at about 33 r/m) of large experimental animals and also very intense radiation of small samples of biological material. By means of pneumatic tubes numerous small "rabbits" containing the Cobalt can be placed either about the large exposure chamber or withdrawn to a small high intensity chamber. It may also be possible to utilize a beam of γ rays from the chest. This apparatus is, of course, primarily a research tool and is not adapted to therapy. It is, however, a very interesting bit of construction and it is worth seeing if you visit Bethesda.

Cobalt also offers the possibility of internal use and preliminary work has already been reported on implantation needles. Since Co is difficult to machine, an alloy of Cobalt 45% and Nickel 55% has been developed. It is called "Cobanic" and can be readily machined into needles, wires and beads. Cobalt responds to magnetic fields and this property can be used to facilitate handling.

In addition Cobalt has advantages relating to supply, cost and possibility of reactivation as compared to Radium. It has virtually homogenous rays and there are no gaseous decay products. A drawback is the shorter half life and the necessity of routine allowance for decay and for repeated calibrations.

How teletherapy with Co^{60} will compare with that from conventional x-ray generators as to cost and convenience remains to be seen.

Before leaving the matter of employing isotopes as substitutes for radium, radon and x-ray there are a few more interesting things to record.

Cesium 137 is a high yield waste fission product from nuclear reactors. It emits 0.66 mev γ (derived from its daughter isotope Ba^{137}) and has a half life of 37 years. (β^- 1.2, 0.5) This γ radiation is about equivalent to that from a one mev x-ray, the discrepancy resulting from the fact that the 1 mev peak voltage from the x-ray machine is higher than the mean effective voltage. It is planned to develop a teletherapy unit employing this isotope, by cooperative effort of the Oak Ridge Institute of Nuclear Physics and Southern Medical Schools.

Sr 90: Superficial radiation of opthalmic and superficial skin lesions by x-ray often involve more depth dosage than desirable and the much less penetrating effects of B radiation are more suitable. Particularly in the case of the eye where there is a known susceptibility to cataract formation, is this of concern. Sr 90 lends itself readily to this type of therapy. It has a half life of 19.9 years (old figures 25 years) and in the process of a double B decay to Yttrium 90 and Zirconium 90 emits B particles with energies of 0.54 and 2.24 mev.

Plaques coated with Sr 90 are used in much the same way as radon and radium D or material impregnated with P^{32}.

Tracerlab provides such plaques and notes a dosage rate of about 20 rep (beta equivalent) at the surface.

Ruthenium 106 in a double B decay to Rhodium 106 and Palladium 106 emits B particles with energies of 0.039 from Ru106 and 2.3 and 3.5 from Rh106. Ruthenium can be electroplated from solution and applied to formed molds. This has obvious clinical possibilities and Gara has reported on the matter in the "Texas Reports on Biology and Medicine", Volume 8, Number 4, Winter 1950, pp 471-479.

We come now to some recent internal application of Au^{198}. This isotope shows a 2.7 day half life and radiation of 0.9 β and 0.41 γ. An interesting application is being made in cases of carcinomatous involvement of the abdominal and pleural cavities. King and his associates at the Bethesda Naval Hospital have just reported on 16 cases. I might summarize the results by indicating that they were distinctly encouraging in the way of palliation. There was usually a well marked decrease in fluid formation, sometimes dramatic clinical improvement and in some cases probable prolongation of life. Dosages were usually in the neighborhood of 100 millicuries. Aside from careful measurement of activity and meticulous radiological safety precautions, the procedure is simple: Excess fluid is removed leaving about 200 cc. The colloidal radiogold is then injected through a special syringe and followed

by three rinsings of the needle with saline solution. The patient is then systematically turned from one side to the other and the foot and head of the bed alternately elevated. Shifts are made every 15 minutes for 4 hours.

The resultant dosage is estimated at 25 r of γ per 100 mc. and 3000 rep (Beta equivalent). This produces mild radiation illness in most cases on the second and third days and lasting for about 1 day. A transitory leucopenia is seen 4-6 weeks later.

The 16 cases are being reported from Bethesda in the American Journal of Roentgenology. They include the following:

2 cases cystadenocarcinoma of the ovary with ascites. One case obtained transient relief of pain and died after 7 months. The other case after three treatments about 10-14 days (94-46 & 102 mc) has required no taps for the past few months and reports good appetite and gain in weight.

<u>Metastatic carcinoma of the breat with pleural effusion</u>: 6 cases. Most of these cases were hopeless and near the end. Some palliation was noted but four died within a few months and another was dying at the time of the report. One is living and shows marked subjective improvement.

<u>Bronchogenic carcinoma with pleural effusion</u>: 4 cases. These cases had also been treated with x-ray (400 kv). One case

now requires no taps - one case is symptom free. Two cases died (few weeks and 5 months).

Rhabdomyosarcoma of the chest with effusion: 1 case. Treated postoperatively as a prophylactic measure. Died in a few months. Evaluation uncertain.

Lymphoblastoma of the Mediastinum with effusion: 1 case. 2 treatments of 72 and 74 mc 4 months apart. Now requires no taps whereas before taps were needed every 6-10 days.

Hodgkin's Disease with effusion: 1 case; 2 treatments; died in about 6 weeks; some transient improvement.

Adenocarcinoma of the rectum with ascites: 98 mc given; dramatic relief of symptoms; however died soon after (month).

Work with colloidal Gold is also underway at St. Albans: One case of cervical carcinoma stage 2 has been treated by injection into each parametric of 50 mc. Three weeks later when hysterectomy and lymphadectomy were performed there was good permeation along the lymphatics. Then structures were well outlined by the reddish colloidal Gold and showed radiation effect histologically.

In general Au 198 has injective possibilities and thus procedure may prove a useful adjunct in selected cases. Difficulties relate to effective distribution and leakage.

P. F. Hahn, Nashville, Tennessee, has used Au198 extensively for infiltration of tumors. The large B component of the radiation permits very high dosage to tumors without excessive destruction of adjacent tissue.

He has also used it for leucemia in dosages of 0.5-1.0 mc. per kgm with good results; he considers it the most satisfactory method.

Allen, Bonebrake and Sherman of St. Louis* suggest use of Au198 for Carcinoma of the Cervix, as part of a plan of treatment which calls for

1. Injection of Au198 in parametric tissue (about 50 mc) transvaginally.

2. Radical abdominal hysterectomy with dissection of lymph nodes (not less than three weeks later recommended).

They plan to use gold more extensively for recurrances in hope that it may prove better than radon inplant or radium needles.

They note the following characteristics of Au198:

Half life 2.69 d

Effective life 3.9 d

94% dose in 11 days

B max 0.98 mev

B av 0.32

* Am Jour Roent + Rad Therapy 66:624-638, Oct 1951
Yr Book of Rad 1952 Pg 305

Maximum ~~ray~~ range in water 3.8 mm
10-20 ion pairs/micron

1 mc gives 900 equivalent roentgen (B) at surface
per 1000 sq cm

Various hospitals are working with Au198 and before long good evaluation of its possibilities will be possible.

It is apparent from the cases recorded that a considerable measure of palliation is possible by use of Au198. It is also apparent that it is not going to work miracles in all cases. It does appear that there is a definite place for it in our armamentarium.

It should be remembered that in the case of death shortly after administration of this isotope that serious radiological safety problems are posed for those performing an autopsy and for the morticians. Their problems are being considered by a special committee of the National Bureau of Standards (headed by Dr. Quimby). In this connection the Atomic Energy Commission has approved certain precautionary measures as noted in the Navy Medical News Letter Volume 20, Number 5, 19 September 1952.

"(1) An up-to-date list of all patients receiving radioisotopes should be maintained in the record office of hospitals;

(2) Names of all deceased persons should be checked against this list and the radioisotopes laboratory promptly notified;

(3) If the deceased had received a therapeutic isotope dose within 2 months the body should be monitored before autopsy or release to a mortician;

(4) The pathologist performing an autopsy should be informed that radioisotopes have been given;

(5) In cases in which the level of radioactivity is less than 1/2 mr/hr no special precautions are necessary;

(6) In cases in which the level is from 1/2 to 6 mr/hr, rubber gloves should be worn and these should be washed with soap and water prior to removal from the hands;

(7) Where the level is over 6 mr/hr a lead apron and dosimeter should be added, thorough cleansing with soap and water or detergent of tables and other surfaces on which blood or other body fluids have spilled should be employed and smoking or eating avoided while wearing the rubber gloves;

(8) In all cases where the level of radioactivity is over 1/2 mr every effort should be made to confine removed body fluids to special vessels, to pour them directly into a drain and flushed copiously with water. When material is retained for further study suitable containers properly

labeled should be used. The mortician should receive instructions similar to those for the pathologist".

In the matter of research there are almost innumerable projects and one could spend much time simply cataloging them.

A great deal of this research is being conducted or supported by the A.E.C. and there are ramifications into all phases of physiology, pathology and biology in general including that of plants.

On this occasion, in view of the scope of the presentation, I will merely mention some of the medical phases we are working with in Naval activities. This I hope will give a fair though very far from comprehensive sample of what goes on.

At present there are five naval hospitals employing radioisotopes and in addition the Naval Medical Research Institute, Bethesda, Md and the Naval Radiological Defense Laboratory at Hunters Point, San Francisco. The hospitals are Bethesda, St. Albans, San Diego, Oakland and Philadelphia. Labs are under general supervision of the Radiological Department of the hospital.

The amount of work that soon piles up is considerable as indicated by a tabulation from Bethesda for the first four months of 1952.

Iodine 131 Tracer Studies	143
Iodine 131 Therapeutic administration	14
Gallium 72 Tracer Studies	26
Diiodofluoroscien Localization Studies	13
Plasma Volume Studies with I^{131}	46
Sr 90 eye application	70
Gold 198 Therapeutic administration	8
P32 Therapy administration	2
	322

St. Albans, since the opening Feb 1952 of its new isotope laboratory (of which we are very proud) reports about 140 studies and treatments up to September.

It is notable from these tables how much the diagnostic use exceeds the therapeutic use for cancer.

One interesting problem being investigated at Bethesda is the simultaneous use of human serum albumin tagged with I^{131} RBC tagged with P32 along with Sodium 24, to study whole blood volumes and sodium space in shock and burn cases. If the technique is perfected application will be made to study plasma space expanders.

At the Oakland Hospital and Naval Radiological Defense Laboratory, Fe59 is being used to study depression of erythropoesis by radiation. The distribution of oxypolygelatin is being studied

there by means of C^{14}, and radiocardiography studies using sodium 24 are being made.

Tumor localization by P32 is being studied at San Diego.

At the Naval Medical Research Institute tracers are being used to study blood metabolism, sulphydryl metabolism, bacterial antigens, burns, and healing of bone fractures.

At the Naval Radiological Defense Laboratory a number of studies of liver metabolism as related to radiological damage are being conducted. Included is the use of S^{35} labeled Bromsulphalein. The fate of thyroxine in the liver is also being studied in collaboration with the University of California. Metabolism in burned tissues is being studied by use of P32 for phospholipid studies and C^{14} labeled amino acids and ammonia for nitrogen metabolism.

Related to radioactive bone seekers such as $Sr^{89\ \&\ 90}$, Yttrium, Cerium, Ur, Pu, Ra and Po there has always been the poorly solved problem of how to remove them from bone. The widespread use of these materials as well as consideration of possible exposure to radioactive products in warfare, lends more than academic interest to the matter. A report on a chelating agent from NRDL shows hopeful results. Versenes or chelating agents have the very desirable property of combining with alkaline earth metals and other metals to form soluble non-ionized

complexes which are excreted largely in the urine. The agent used was EDTA (ethylene diamine tetraacetic acid) in the form of sodium and calcium salts. By giving sodium EDTA followed by Ca EDTA substantial amounts of Y^{91} were caused to be excreted. The Na salt lowers the blood Ca ion level causing a shift of Ca from the bone. Both the Na and Ca salt exchange Ca for Y. The Ca acts as a adjuvant and also makes it possible to administer more of the chelating agent. In large amounts the Na salt is toxic whereas the Ca salt is innocuous.

Our English confreres are very active in the field and it is worth while to mention a few items from the Isotope Number of the British Medical Bulletin (Vol. 8, Number 2-3, 1952). They cover a wide field and we find consideration of assay, detection and measurement, application of autoradiography and stripping film, the various uses of radioiodine including labeled diiodofluorescein, intracavitory use of Au198, a number of metabolic and other research problems; also the use of balloons containing Na24 and Br82 in the bladder. Their results in general parallel our own and there is no time to report in detail. Suffice it to note a few points of special interest: The use of Au198 to control pleural and asciting of malignant origin has given them 21 cases of fair or good palliation out of 34 cases; I^{131} labeled diiodofluoroscein has failed to give definite information as to size and location of brain tumors; Na24 has been found useful in plastic surgery for evaluating circulation in pedicle flaps; Na24 and Br82 which are B γ emitters of short half life have been used in balloons

to irradiate the bladder employing about 150 cc. of radioactive solution and about 800 mc (Br82) - results encouraging - urethrostomy involved in the male. In addition to the above CAPT J. J. Hays (MC), USN in personal communications mentions use of Au198 seeds for implantation by the novel method of shooting them from a pistol like contravance. Scott in the 1951 Year Book of Radiology reports the use of Ta182 at the Royal Cancer Hospital for bladder tumors. Characteristics: 115 d; B 0.5, 1.1; γ large cascade 0.05-1.2. It is employed as Platinum covered wire loops of special design which can be implanted beneath the tumor and secured to the eye of the catheter by ligature. Upon removal of the catheter ligatures and wires follow through the urethra. This method obviates reopening of bladder as is necessary with radium needle implants; also any foreign body reactions such as may occur with radon seed implants.

At this point it is high time to desist and in closing I would like to remind all of us in radiology, including myself, to take time to keep abreast of our responsibilities in the matter of isotopes. They are very much here to stay and our help is needed on behalf of our patients and colleagues. We need also to render that help as a matter of enlightened self interest as promoting more intimate clinical contacts with patients and staff (things which we readily tend to lose in our specialty) and increasing our professional scope, ability, usefulness and prestige. If we should neglect this field everyone will be the poorer thereby.

In closing it is very impressive to note that in the medical application of ionizing radiation we now have such a remarkable wealth of modalities in the form of radioisotopes and also apparatus. The former we have just discussed. The latter now ranges from "Grenz" ray generators of about 10 KV to multi-millio volt particle accelerators. Certainly it is all very wonderful but let us remember what it is all about basically. The effects of ionizing radiation, whatever the energy or mean of application, remains fundamentally the same. What we must think about, plan for and use all the various means for, is to put effective dosage in the lesions and spare normal tissue. We are accomplishing a great deal along such lines and radiation therapy is rapidly becoming more effective and precise in our medical centers. It remains to carry improved methodology beyond these centers to accomplish better work and save more lives throughout the whole country. It also remains to do more basic research. In spite of our improved methods, damage to normal tissue seriously cripples our efforts. We need to find ways of making tumor cells more vulnerable, to increase the differential. Some promising leads are developing and it is hoped that there will be more work along these lines and substantial progress in the future.

Marshall

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APPENDIX

TABLE OF PRINCIPLE RADIOISOTOPES OF MEDICAL INTEREST

Carbon 11	20.5 m	B^+ 0.97
Carbon 14	6360 y	B^- 0.155
Sodium 24	15.04 h	B^- 1.39; γ 2.78, 1.38
Phosphorus 32	14.3 d	B^- 1.708
Sulphur 35	87.1 d	B^- 0.167
Calcium 45	152 d	B^- 0.255
Iron 55	2.94 y	X (K)
59	46 d	$B^- \begin{Bmatrix} 0.26 \\ 0.46 \end{Bmatrix}$, $\gamma \begin{Bmatrix} 1.1 \\ 1.3 \end{Bmatrix}$
52	7.8 h	B^+ 0.55
Cobalt 60	5.26 y	B^- 0.32 γ 1.17, 1.33
Cu 64	12.8 h	B^- 0.57; γ 0.66; X
Cu 67	58.5 h	B^- 0.54
Ga 67	78 h	γ 0.18, 0.3, 0.09; X
Ga 72	14.08 h	B 0.6-3.2; γ 0.6-2.5
Br 82	35.87 h	B 0-46; γ 0.05-1.35
Sr 89	53 d	B 1.5
Sr 90	19.9 y	B 0.54 (and 2.24 from Y90)
Ru 106	1 y	B 0.039 (and 2.3 - 3.5 from Rh 106 plus γ 0.5-2.2)
I 131	8 d	B 0.32, 0.6; γ 0.08-0.73
Cs 137	37 y	B 1.2, 0.5; γ 0.67 (from Ba^{137})
Au 198	2.7 d	B 0.97; γ 0.41, 0.69, 1.1
Pb 210 (RaD)	25 y	B 0.03; γ 0.007-0.047
Em (Ru)	3.8 d	α 5.49

DEVELOPMENTS IN RADIOLOGICAL DEFENSE

12 May 1953

Civil Defense Research Associates, Inc.

also
Rad Def. Group - Nav Shipyard Brooklyn

DEVELOPMENTS IN
RADIOLOGICAL DEFENSE

NEW LOOK AT RADIATION THERAPY

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NEW LOOK AT RADIATION THERAPY */

By

Rear Admiral C. F. Behrens, MC, USN

Periodic reappraisals are always in order in medical affairs to evaluate the new and to avoid discarding older methods prematurely. Startling developments bask in the limelight and much that is good may be left in the dark, forgotten and "ganz aus der mode" as expressed by Goethe. There are fascinating innovations in radiation therapy as well as in other fields and our interest naturally turns to radioactive isotopes and multi-million volt machines. However, on this occasion I would like to hark back to more prosaic things and leave detailed consideration of wonder isotopes and super-terrific apparatus to other occasions. However, in passing I might remark that these newer modalities in competent hands and used with precision have much to offer and we should be alert to use them where appropriate. It is not likely that miracle cures are just around the corner but there are very definite benefits or possibilities. High energy apparatus puts the maximum radiation dosage where you want it in deep therapy with less skin damage, less total dosage absorbed and lessened general effects. Particulate rays both from machines and such implements as Sr^{90} applicators bring possibility of better superficial effects with lessened deep dosage. The therapeutic use of isotopes is progressing and aside from this, research by tracer methods is bringing increasing knowledge of

*/ Prepared for the Radiation Therapy Number of the Mississippi Valley Medical Journal.

metabolism including that of tumors. Thereby we will gain insight into etiology and pathology that should prove of great profit.

Coming to the main topic it is well to recall that early in the century radiation was thought of as a great cure-all and was tried without much discrimination on virtually everything. This included the all too free use of radium salts internally. Out of this exuberance of effort there gradually emerged rational uses. Malignant tumors, of course, were promptly appropriated and have occupied the center of the radio-therapeutic stage ever since. Then too inflammation, infections, arthritides, dermatoses, keloids, leucemias, neuralgia, herpes, angiomas, tuberculor glands often responded well and it is of some of these that I would speak particularly.

Infections. The advent of sulfonamides and antibiotics has relegated x-ray therapy to a minor role here. This is probably as it should be but there should not be complete neglect. Complete forgetfulness will entail perhaps not unnecessary deaths but certainly instances of delays, complications and needless suffering. In severe infections despite antibiotics and all else, things occasionally come to a standstill. I have seen this several times in Ludwig's angina, deep cellulitis and again in middle ear infection and mastoid involvement. It appears that there is localized blockage which prevents access of antibodies and antibiotic agents. In such

cases radiation therapy particularly if not delayed unduly may aid tremendously. Improvement is probably due to relief of congestion, better circulation and possibly liberation of antibodies. In general it will be well to consider x-ray in many instances of furnucles, carbuncles and various infections especially about the face.

Requisite dosages are small, 50 to 100 r, and there need be no fear of exciting a skin reaction in cases receiving sulfonamides. We have treated many cases of ear infection receiving sulfonamides without any such difficulty whatever.

Regarding middle ear disease, it is well to mention that recurrent cases of otitis media are often predisposed to by adenoid tissue some of which may extend into the eustachion orifices sufficiently to cause poor drainage. Adenoid tissue so located is apt to escape surgical removal. Radiation therapy becomes truly a God-send in such cases and should never be neglected. X-ray is more appropriate here than radium in my opinion, and the requisite dosage is so moderate and the areas so circumscribed that untoward after-effects should not be encountered with proper techniques.

Related to the middle ear difficulties just mentioned is the so-called aero-otitis which results from inadequate or slow equalization in pressure within and without the ear during changes in altitude. Radium and perhaps to a lesser extent, x-rays, have been used for this condition with considerable success. X-ray,

in competent hands, I would prefer, by reason of ease, safety and wider area treated. The condition probably relates to excess lymphoid tissue producing more or less blockage of the eustachian tube. Moderate dosage suffices and with either method it is possible to achieve good results without damage; there should be great care and competent radiological supervision in any event.

Arthritis and Related Conditions. Once more we have a virtually universal group of ailments for which new miracle drugs in the cortisone family have become available. It is, however, fortunately recognized that these remedies must not be used with the abandon that antibiotics have been poured into people. Radiation still has a place in the arthritis armamentarium and in particular many cases of painful shoulder. This extremely frequent ailment is more often due to pathology about the joint than in it. So we hear of para-arthritis, peri-tendinitis, bursitis and still other terms; accounts are to be readily found in current journals and I would only note that most severe acute cases (and some are agonizingly severe), will respond dramatically to moderate dosage with x-ray. It is also true that many cases will subside with use of conventional methods and that such methods, of course, should ordinarily come first; nevertheless quite a few cases are excessively painful and refractory. It then becomes sensible to refer them for radiation therapy without much delay.

Chronic cases respond sluggishly and not so well. Cases where there is pain from nerve root irritation (cervical arthritis and its complications) are also resistant but will also often respond to rather protracted treatment.

Acute exacerbations in the course of hypertrophic or degenerative arthritis often respond well.

Rheumatoid arthritis presents special problems on the score of chronicity, recurrences amd more irregular response. However, the Marie-Strumpell type of spinal involvement responds very well and such cases are best referred early.

Chronic leucemias respond well to x-ray and also to P32 and nitrogen mustard. The decision which to use involves judgment of the individual case but I think it is safe to say that most can be treated readily and conveniently with x-ray. The same applies to Hodgkin's Disease. Combined therapy may be the best in some cases and there may be possibilities in radioactive colloidal gold.

In Polycythemia vera the preference now runs to P32 but it seems that the general practitioner has a particular role to play here in which good clinical judgment is needed. There is a limit to the number of times radiation may be used with relative safety to produce remission. Thus it is well to control the disease by conventional methods, particularly venesection as long as safe. On the other hand too long a wait will entail the dangers of cerebral accidents and other complications.

Radioiodine for therapy and diagnosis also involves careful judgment by the clinician. This has been so well and frequently publicized that we will pass on with the mere mention. This agent has now become the remedy of choice in selected cases of hyperthyroidism and an important adjunct in certain cases of thyroid carcinoma.

In Herpes zoster we find a condition in which radiation therapy is very commonly forgotten or neglected. Some cases are mild and need nothing but local treatment and mild analgesics. However, some of the cases develop excruciating pain and it has been my lot to encounter some of them more or less accidentally on duty rounds and find that no one had even thought of radiation therapy. By employing x-ray therapy early you can prevent much suffering and find yourself with an exceedingly grateful patient. It is only fair to note, however, that some cases particularly in elderly people tend to drift into chronic neuralgic pain and may prove resistant. Benefit is usually derived but not in the dramatic manner that we like to see and often do.

Trigeminal neuralgia commonly calls for various injections and eventual surgery. It should not be forgotten, however, that radiation therapy can ordinarily be relied on to produce remission. It cannot, of course, be used with unlimited repetition throughout many years, but it may well prove safe and convenient as an interim or exploratory measure.

Birth marks due to hemangoimata should not long be neglected particularly if somewhat prominent; they may grow larger and more disfiguring. Radiation either from Radium or x-ray is very effective. A serious problem arises, however, where epiphyses are in the field. The future answer may well be the electron beam since there is very sharp falling off in depth dosage when energies appropriate to superficial lesions are used.

Among skin diseases occasional cases of acne should receive treatment to avoid extensive scarring. Tinea capitis may call for epilation by x-ray. Other stubborn fungus infections are often benefitted but there needs to be considerable prudence in the way of reserving radiation for difficult cases and avoiding too many repetitions. Radiation has cumulative effects which can prove disastrous. The same caution applies to psoriasis and other chronic or recurrent conditions.

Tuberculous glands are relatively infrequent these days. If they are encountered it is well to remember that radiation therapy has proven very helpful in this condition.

Sterility. For a number of years radiation has been advocated as a means of curing sterility in women. The procedure has been to give small so-called "stimulating" doses to the pituitary and ovarian regions. It appears that a considerable measure of success has attended such efforts but lately the question has been raised as

to genetic effects. The issue has been not a little confused by lack of understanding as to how genetic effects are likely to manifest themselves and it seems proper to review this matter briefly.

The dosages employed are likely to approximate 50-75 r to the pelvis given three or four times and resulting in roughly 50 r to the ovaries. How serious is this? A number of subsequent normal births attest the fact that immediate effects are negligible and that possible harm relates to genetic mutations.

Regarding these the following points can be made:

Mutations are mostly recessive and so may not show for a number of generations.

They are increased by radiation and are harmful to a vastly preponderant extent. The increase is cumulative.

Quantitatively it appears probable that something less than 100 r will double the normal rate. It is also stated that a 25% general increase in the human race would be disastrous. However, such a general increase would depend on widespread exposure and not the occasional cases involved in therapy such as we are considering. Practically it amounts to adding a few more "time bombs" as the geneticist Dr. Müller once termed recessive mutations, to the stock we already have. It seems that if the affected individuals produce some generation of descendants then there is .

an increased chance that somewhere along the line a genetic aberration will appear.

Clinicians tend to view the matter lightly whereas geneticists are not a little concerned. Quantitative data for humans is far from precise and research still has a long way to go but the present trend appears to favor the serious view. Certainly this application of therapy should be a last resort and with minimal dosage.

This brings our little summary about to the end and in conclusion I would only once more suggest that in our very justifiable enthusiasm for our new therapeutic agents, let us not forget the place of radiation therapy in many common conditions.

NEW LOOK AT RADIATION THERAPY

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1910 words

B.F.
L.C.

NEW LOOK AT RADIATION THERAPY */

By

Rear Admiral C. F. Behrens, MC, USN

Charleston, South Carolina

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B.F.L.C.

Infections

~~Infections~~. The advent of sulfonamides and antibiotics has relegated x-ray therapy to a minor role ~~here~~ in the treatment of infections. This is probably ok. 9 10 as it should be, but there should not be complete neglect. Complete forgetfulness will entail perhaps not unnecessary deaths but certainly instances of delays, complications and needless suffering. In severe infections, despite antibiotics and all else, things occasionally come to a standstill. I have seen this condition several times 11 in Ludwig's angina, deep cellulitis and again in ~~middle ear~~ infection of the middle ear 12 and ~~mastoid~~ involvement of the mastoide. ~~It appears that there is~~ a localized blockage 13 ~~which prevents~~ seems to prevent access of antibodies and antibiotic agents. In such 14

made

cases radiation therapy, particularly if not delayed unduly, may aid tremendously. Improvement ~~is~~ probably ~~due to~~ results from relief of congestion, ~~better~~ improved circulation and possibly liberation of antibodies. In general, ~~it will be~~ one might well ~~to~~ consider x-ray in many instances of furnucles, carbuncles and various infections, especially about the face.

15

16

Requisite dosages are small, 50 to 100 r, and there need be no fear of exciting a skin reaction in ~~cases~~ patients receiving sulfonamides. ~~We~~ I have treated many ~~cases of~~ patients who had ear infection and who were receiving sulfonamides without any such difficulty whatever.

17

~~Regarding middle ear disease, it is well to mention that~~ Recurrent cases of otitis media are often predisposed to by adenoid tissue, some of which may extend into the eustachian orifices sufficiently to cause poor drainage. Adenoid tissue so located is apt to escape surgical removal. Radiation therapy becomes truly a Godsend in such cases and should never be neglected. X-ray is more appropriate here than radium, in my opinion; and the requisite dosage is so moderate and the areas so circumscribed that untoward aftereffects should not be encountered ~~with~~ if one uses proper techniques.

18

Related to the middle ear difficulties just mentioned is the so-called aero-otitis which results from inadequate or slow equalization in pressure within and without the ear during changes in altitude. Radium and perhaps to a lesser extent, x-rays, have been used for this condition with considerable success. X-ray,

in competent hands, I would prefer, for its ~~by reason of~~ ease, safety and (19)
wider area treated. Aero-otitis ~~The condition~~ probably relates to excess (20)
lymphoid tissue which ~~producing~~ more or less block~~age~~s ~~of~~ the eustachian (21)
tube. Moderate dosage suffices, and with either method it is possible to achieve good results without damage; there should be great care and competent radiological supervision in any event. B.F. L.C.

center

Arthritis and Related Conditions. Once more we have a (22)
virtually universal group of ailments for which new miracle drugs in the cortisone family have become available. It is, however, fortunately recognized that these remedies must not be used with the abandon that antibiotics have been poured into people. Radiation still has a place in the arthritis armamentarium and in particular in many cases of painful shoulder. This extremely frequent ailment is more often due to pathology about the joint than in it. So ~~we~~ one hears (23)
of para-arthritis, peritendinitis, bursitis and still other terms; accounts are to be readily found in current journals, and I would only note that most severe acute cases (and some are agonizingly severe) will respond dramatically to moderate dosage with x-ray. It is also true that many cases will subside with use of conventional methods and that such methods, of course, should ordinarily come first; nevertheless, quite a few cases are excessively painful and refractory. It then becomes sensible to refer them for radiation therapy without much delay.

Behrens-5

Chronic cases respond sluggishly and ~~not so well~~ unsatisfactorily. Cases ~~where~~ in which (24)
there is pain from ~~nerve root~~ irritation of the nerve roots (cervical arthritis and (25)
its complications) are also resistant but will also often respond
to rather protracted treatment.

Acute exacerbations in the course of hypertrophic or
degenerative arthritis often respond well.

Rheumatoid arthritis presents special problems on the score
of chronicity, recurrences and ~~more~~ irregular response. However, (26)
the Marie-Strümpell type of spinal involvement responds very well, BF L.C
and such cases are best referred early.

Other Conditions (27)

Chronic Leukemias ~~Chronic Leucemias~~

~~Chronic leucemias~~ respond well to x-ray and also to P32 and (28)
nitrogen mustard. The decision of which to use involves judgment of
the individual case, but I think ~~it is safe to say~~ that most can be (29)
treated readily and conveniently with x-ray. The same applies to
Hodgkin's disease. Combined therapy may be the best in some cases,
and there may be possibilities in radioactive colloidal gold.

In polycythemia vera, the preference now runs to P32, but ~~it~~ (30)
~~seems that~~ the general practitioner here has ~~a~~ to play a particular role ~~to play~~
~~here~~ in which he needs good clinical judgment ~~is needed~~. There is a limit
to the number of times radiation may be used with relative safety
to produce remission. Thus it is well to control the disease by
conventional methods, particularly venesection as long as safe.
On the other hand, too long a wait will entail the dangers of
cerebral accidents and other complications.

more

Behrens-6

Radioiodine for therapy and diagnosis also ~~involves~~ requires careful (31)
judgment by the clinician. This form of therapy has been so well and frequently (32)
publicized that we will pass on with the mere mention. This agent has now become the remedy of choice in selected cases of hyperthyroidism and an important adjunct in certain cases of thyroid carcinoma.

is

Herpes Zoster is a condition in which radiation therapy is very commonly forgotten or neglected. Some cases are mild and need nothing but local treatment and mild analgesics. However, some patients dedevelop excruciating pain; and encountering some of them more or less accidentally on my rounds of duty, I have found that no one had even thought of radiation therapy. By employing x-ray therapy early, one can prevent much suffering and find himself with an exceedingly grateful patient. However some cases, particularly in elderly people, tend to drift into chronic neuralgic pain and may prove resistant. Benefit is usually derived but not in the dramatic manner that one likes to see and often does.

Trigeminal neuralgia commonly calls for various injections
and eventual surgery. ~~It should not be forgotten,~~ However, ~~that~~ (35)
radiation therapy can ordinarily be relied on to produce remission. It cannot, of course, be used with unlimited repetition throughout many years, but it may well prove safe and convenient as an interim or exploratory measure.

Brode

Behrens - 7

<u>Birth marks</u> ~~due to~~ caused by hemangoimata should not long be neglected, (36)
particularly if somewhat prominent; they may grow larger and more
disfiguring. Radiation either from ~~R~~radium or x-ray is very effective.
A serious problem arises, however, ~~where~~ when epiphyses are in the field. (37)
The future answer may well be the electron beam, since there is a very
sharp falling off in depth dosage when energies appropriate to
superficial lesions are used.

<u>Among skin diseases</u> occasional cases of acne should receive
treatment to avoid extensive scarring. Tinea capitis may call for
epilation by x-ray. Other stubborn fungus infections are often
benefit~~t~~ed, but ~~there needs to be considerable prudence in the way~~ one must be very careful to
~~of~~ reserv~~ing~~e radiation for difficult cases and avoid~~ing~~ too many (38)
repetitions. Radiation has cumulative effects which can prove
disastrous. The same caution applies to psoriasis and other chronic
or recurrent conditions.

<u>Tuberculous glands</u> are relatively infrequent these days,
~~If they are encountered it is well to remember that~~ radiation (39)
therapy has prove~~n~~d very helpful in this condition.

<u>Sterility</u>. For a number of years radiation has been advocated
as a means of curing sterility in women. The procedure has been to
give small so-called "stimulating" doses to the pituitary and ovarian
regions. ~~It appears that~~ ~~a~~ A considerable measure of success has (40)
apparently attended such efforts, but lately the question has been raised as

more

Behrens
8

to genetic effects. The issue has been not a little confused by lack of understanding as to how genetic effects are likely to manifest themselves. ~~and it seems proper to review this matter briefly.~~ (41)

The dosages employed are likely to approximate 50-75 r to the pelvis given three or four times and resulting in roughly 50 r to the ovaries. How serious is this result? A number of subsequent normal births attest the fact that immediate effects are negligible and that possible harm relates to genetic mutations. (42) (43)

Regarding these the following points can be made:

Mutations are mostly recessive and so may not show for a number of generations.

They are increased by radiation and are harmful to a vastly preponderant extent. The increase is cumulative.

Quantitatively ~~it appears probable that~~ something less than 100 r will probably double the normal rate. It is also stated ~~It is also stated~~ that a 25% per cent general increase in the human race would be disastrous. However, such a general increase would depend on widespread exposure and not the occasional cases involved in therapy such as we are considering. Practically, it amounts to adding a few more "time bombs," as the geneticist Dr. Müller once termed recessive mutations, to the stock we already have. ~~It seems that~~ If the affected individuals produce some generation of descendants, then there is (44) (45) (46)

more

an increased chance that somewhere along the line a genetic aberration will appear.

Clinicians tend to view the matter lightly, whereas geneticists are not a little concerned. Quantitative data for human~~s~~ beings is far from precise, and research still has a long way to go; but the present trend appears to favor the serious view. Certainly this application of therapy should be a last resort and with minimal dosage.

~~This brings our little summary about to the end and in conclusion I would only once more suggest that in our very justifiable enthusiasm for our new therapeutic agents, let us not forget the place of radiation therapy in many common conditions.~~

END

A FEW NOTES ON ATOMIC MEDICINE

(General Article Based on the Material in the Wochenschrift Notes)

A FEW NOTES ON
ATOMIC MEDICINE

German
Wochenschrift

A FEW NOTES ON ATOMIC MEDICINE

It is indeed an honor to be invited to speak to this important civic organization. I can only hope that in return I may be able to shed a little light on a very complex subject replete with many ramifications and also subject to extraordinary publicity.

In this particular field modern science, as you are all aware, has given us new approaches and vastly difficult problems. It has made possible events which have been startling, staggering, and in many respects profoundly dismaying. These have mushroomed like the cloud of the atomic bomb itself from the original discovery of nuclear fission by Hahn and Strassman in Germany. At the time This produced a tremendous sensation among a handful of nuclear physicists and even a few popular articles appeared some years ago mentioning U^{235} and speculating on energy possibilities. However, general appreciation was naturally limited since the basic phenomena were not generally grasped. It could hardly be otherwise even though we were probably not as obtuse in the matter of appreciating news as the old darky servant in a comic recitation made famous a generation ago by Nat Wells (No news are what killed the dog).

At all events astounding phenomena of all sorts must be dealt with. We find ourselves with a new fantastic physics, nuclear reactors of varied types including power types for propulsion of ships; atomic bombs and artillery and also liberal supplies of radioisotopes.

This last feature is the one that physicians would like to exploit beyond all else but it is not possible to neglect nuclear weapons. We have all read accounts of what they can do and have seen illustrations and movies; some of us have seen them in action. As if that were not enough bigger and better blasts seem to be in store by way of the so-called hydrogen, ~~or~~ fusion or thermonuclear bomb.

Dealing with the matter of bombs briefly, it is well to point out a few considerations which color the general defense picture. First of all let us remember that it is not safe to indulge in a Rip Van Winkle snooze in the matter of preparedness and civil defense. Even though immediate danger may be discounted, one cannot prepare efficiently or economically overnight. The potentialities of attack are there and we must not forget this. Naturally all the military services are studying the problem with the greatest concern both from defensive standpoint and effective retaliation. However, civil defense is also a requisite and it should be remembered that a really effective civil defense may well act as a deterent. The more vulnerable we are the greater the temptation for an enemy to resort to a surprise attack. An efficient civil defense and an increasing spread of industry greatly reduce the profit of attacks and likelihood of demoralization. Civil defense also I might note will pay big dividends in the case of peacetime calamities; ~~though~~ these unhappily are not too infrequent.

Coming to my own province, that of medicine, atomic weapons mean not only colossal numbers of casualties ~~destruction~~ by the more familiar agencies of burns and blast, but the introduction of radiological hazards. Japanese figures indicate an over-all fatality rate from radiation effects, roughly estimated at fifteen per cent. Thus the more familiar injuries are sure to be grossly preponderant & we must plan accordingly. Yet aside from that fifteen per cent, which is truly a considerable figure notwithstanding, it must be remembered that many other casualties will have the course of illness and treatment complicated by the effects of ionizing radiation. This factor must be calculated into overall plans for dealing with an atomic catastrophe. Let us see what that means in terms of relief and therapy aside from the gross need for dealing as effectively as possible with huge numbers of casualties, namely, estimated at more than 50,000 from a single bomb.

In the first place, air bursts at a moderate elevation are apt to be the means employed and that means that radiological contamination is apt to be a minor consideration and of little, if any, concern in prompt rescue work. The principal radiation effect will be from gamma rays and people exposed within a range of a mile or so from the epicenter, whether apparently injured or not, are apt to develop serious and at times fatal radiation illness. Many of these, although apparently well, or affected to minor degree, at first, become very ill ten days to several weeks later and so it becomes most advisable to make provision for such later developments. Otherwise, scattered refugees may fall ill unexpectedly in various locations and with inadequate provision for their needs, causing a resulting tendency to widespread demoralization.

In the case of those injured by burns and other trauma within the zone of radiation effects, the complicating factor of radiation illness must be dealt with. This may influence decisions as to open operations, since radiation illness of severe degree will entail tendencies to hemorrhagic effects, nutritional problems and lowered resistance to infection even to ~~the~~ extreme degrees ~~seen in agranulocytosis~~. It will also mean a greater burden on the medical and nursing staff and increased need for the biological types of antibiotics, than would ordinarily be anticipated. The sulpha drugs ~~sulphonamides~~ would be largely interdicted in cases of radiation illness because they lower ~~due to their depressant effect upon~~ the leucocytes count. Whole blood and to a lesser extent plasma will also be needed in larger measure. We now have, fortunately, a plasma substitute in the form of dextran which will prove ~~should~~ be a great boon. The services are using this now.

In the matter of genetics, permanent sterility and the birth of monstrosities are commonly feared but do not appear important. Of more concern is the increase in remote hereditary harm in future generations which may result not only from acute atomic explosion radiation but also from cumulative effects of excessive small exposures. Precise figures are still uncertain but from a statistical standpoint large numbers of people would have to be affected in order to occasion serious results to the general population. Nevertheless the radiation factor is not to be forgotten entirely because radiation increases the ~~it seems there are~~ already ~~a~~ considerable number of damaging ~~recessive~~ factors called mutations carried along in the human germ plasm; and aside from ~~general~~ considerations ~~and since by far the greater number of these are unfavorable.~~ of the general population, we must never forget the possibilities of harm to individuals + particular families. Thus in this day + time the medical world is more alert + more careful than ever before in the matters of radiological safety not only as pertains to atomic weapons but in every day life.

Another set of problems would arise if a subsurface burst occurred roughly similar to that carried out at Bikini. Such may be anticipated where a considerable amount of reasonably deep water is sufficiently near a profitable target. The main complicating factor then becomes the resultant deluge of water, foam and mist heavily contaminated with radioactive fission products. Flash and blast effects will be notably reduced, but contamination of personnel, buildings and materiel ~~will~~ would cause much trouble. It should, however, be noted that the picture sometimes drawn of cities deserted for thousands of years, although quite dramatic, is definitely overdrawn.

Most fission products decay rapidly, usually in chain fashion by beta decay, and radioactivity declines very rapidly. This has very practical implications. Rescue work may have to be delayed ~~but~~ or limited but even in a matter of hours ~~some efforts can be made~~ it can be well under way. Again if personnel, protected in buildings, subways and other shelters will forbear to rush out immediately, a great reduction in the radiation casualty rate will be made. ~~A~~ very liberal degrees of controlled access to contaminated area ~~should~~ would be possible within a few days; and although certain long-lived radioactive materials ~~will~~ would present serious problems indefinitely, the picture is far from as grim as often painted.

Radiological warfare is often mentioned in lurid fashion and to be sure it ~~could from~~ can prove a seriously harrassing agent. Nevertheless in the reports from the Department of Defense, it is considered of far less peril than atomic bombs. Psychological + panic problems might well be more important than the physical menace.

Coming now to the medical and biological application of radioactive

isotopes we find that such employment takes two main directions. First, there is the application to patients for therapeutic and ~~occasionally~~ diagnostic purposes. Then there is use in research, often ~~usually~~ by tracer methodology. In addition, and as a sort of adjunct to radiation safety and practical applications, there are numerous studies involving the toxicity and metabolism of the isotopes themselves.

Considering treatment ~~the first~~, it is natural to entertain the hope that perhaps an isotope may be found that will act as the magic weapon with which to conquer cancer completely, once and for all. Such, however, has not been found and it may well be that this complete measure of success will continue to elude us. There are several inherent difficulties. These are related to a sufficient degree of selective absorbtion of the particular elements concerned, convenient and effective types of radiation, suitable half life and relative freedom from toxic effects. We must also consider radiological hazards and precision in dosimetry. Administration of radioactive isotopes in a proper manner calls for much specialized knowledge, skill and training. Accordingly in the United States, hospitals or clinics desiring to obtain isotopes for clinical use, are required to have a supervisory committee composed of experts in internal medicine, hematology, radiation therapy and radiation physics.

Some Isotopes ~~most~~ frequently used in clinical practice are I^{131} P^{32} ~~and~~ Na^{24}, Au^{198}, Sr^{90} (plaques) and Co^{60}.

As already indicated these isotopes are far from cure-alls.

~~Others do not, so that~~ Careful selection of cases and preliminary studies are requisite. Certain cases of thyroid disease ~~are~~ also suitable for ~~this~~ radioiodine form of therapy. Again in certain cases of coronary heart disease where lessened function of the thyroid is desired, I^{131} may be the method of choice in accomplishing this. P^{32}, as is well known, has beneficial effect in a number of conditions such as certain diseases of lymph glands; also in blood diseases and occasionally skin lesions. However, our old friend, X-ray therapy, is not to be forgotten. It often does just as well. Gold is used to attack cancer; Sr 90 for skin lesions; Co60 can be used like radium.

Such therapeutic and diagnostic uses are of course most interesting and often spectacular, but it is quite likely that the more slow and toilsome application of radioactive isotopes to biological research will yield the most long range benefit. The ability to trace important elements and the chemical molecules or radicals to which they are attached is naturally a great asset, and that is what the use of radioactive isotopes as tracers makes possible. All this is a subject for chapters, if not volumes, but it is appropriate to mention a few salient features here.

Methods of application include rate of appearance and disappearance of the radioactive elements along with quantitative radiation studies of tissue, tissue fluids and execretory products. In addition radioautography is extensively employed and it is often of great value to use radioactive tracers in partition chromatograph where the substance concerned spreads along special types of paper.

Amongst the matters elucidated we can enumerate some that are very interesting and important. The concept that all body tissues are in a

constant state of flux or "turnover" has been greatly amplified. The status of chemical bonds in organic compounds is being clarified and we find that certain bonds usually thought of as closed are in reality often open in the living cell. The transfer of water and doluble salt is becoming more accurately determined.

Thus new pages in metabolism, diagnosis and therapy are being opened and we can expect that the new few decades in medicine will be as brilliant and dazzling as those which brought us so many triumphs in the past.

This brings to a close this brief account. It is hoped that although sketchy and elementary it will serve to bring these matters into proper perspective and stimulate those interested (and it is hoped there are many) to more detailed study of the manifold phases involved.

No modifications as per original

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MEDICAL ASPECTS OF ATOMIC DEFENSE

(Sertoma Club, Charleston, SC)
23 October 1953

MEDICAL ASPECTS OF
ATOMIC DEFENSE

Med Aspects of Atomic Defense

MEDICAL AND CIVIC ~~PROBLEMS IN~~ SPECIAL WEAPONS DEFENSE

It is always an honor to be invited to speak to an important civic organization such as this. It is of course also a challenge to the speaker to come up with something worth while for the audience.

The times and my own particular background have brought me to the topic of nuclear and other special weapons as related to medical and civic problems. This topic, I hope, won't be taken amiss on the grounds that it is of concern only for ~~the large~~ huge metropolitan areas. As a matter of fact, all cities with important military installations are natural targets, omit and aside from that, All cities will at least have supporting roles to play at very least.

There has been an ever present need for some measure of defense against disasters since prehistoric days when mankind first developed a communal type of existence and particularly since the advent of large cities. The diversions and opportunities of city life have always ~~had~~ held an irresistible appeal for many people despite fulminations against the immorality and viciousness often rampant in cities and again despite all the poetic raptures anent ~~a~~ simple ~~frugal~~ life in the country; so, great concentrations

of human population have featured human existence throughout all recorded history. Due to the resulting increase in vulnerability, fires, floods, storms, volcanoes, earthquakes, famine and pestilence have all taken frightful toll; add finally, warfare. Mankind has an unhappy predelection for settling serious and heated disputes by violent and desperate means; quite a few of us, too, are not at all adverse to murderous means of gaining power, wealth, or territory. Wherefore wars and rumors of war have been perpetual; and once war starts indiscriminate blood letting is just around the corner. Fury mounts, compunctions vanish, and conscience takes a vacation. Finally, stern necessity, real or fancied, may call for wholesale destruction which would ordinarily be repugnant or unthinkable. At all events regardless of speculations, the hideous record is there and we have no reason to feel that we have seen the end of it.

omit

As we scan the pages of history the sum total of catastrophe is impressive, in fact staggering. However, disasters usually strike rather haphazardly and in a given locality infrequently. We tend, therefore, to neglect earnest consideration of them, and avoid the trouble and expense of preparedness unless the Sword of Damocles is right over our own heads.

Well, it is over our heads now - there can be no doubt of it. With the flash and the rumbling roar of the nuclear explosions in Japan, all the elements of mystery, sensationalism, + spectacular horror ~~and gruesome destruction of life~~, combined to shock complacency; and this has been reinforced in recent years by the emergence of the H bomb. Nevertheless, we still seem to find it difficult to accept the imminence of peril though there is obvious need for realistic preparation on a large scale. There is endless planning, much writing and plenty of talk - all of which is important and essential, but it is time we really went to work seriously.

That is not to say that we are sure to be bombed and that very soon. It is to remind ourselves that the capability is now there. We find ourselves confronted by an imposing collossus possessing great military strength, and wishing us no good. It seeks to dominate. It seeks to overawe and cultivates an aura of invincible might. It depicts itself as the sole repository of political and social wisdom and virtue. It obviously seeks world dominion and we are very much in the road. Moreover, a heavy handed police state can't well tolerate free and well to do neighbors - there are too many glaring and tempting comparisons for its own people.

A healthy regard for the military and industrial capabilities of our own country has exercised constraint and aside from that the ruinous prospect of two huge countries hurling long distance atomic thunderbolts at each other's vital targets is even more idiotic than the more conventional warfare which has marred the face of the world. It is probable too that this latest group of would-be world conquerors still hopes to ruin us by impaling us on the horns of a dilemma; prepare in full measure and wreck your economy; neglect preparation and become ripe for defeat. There has long been hope and expectation in the red world that our economy will fail in a complete debacle. Then comes the revolution with Communists pulling the strings. Accordingly, certain factors tend to allay fears of early major warfare. It should be realized, however, that hope must not become a too confident expectation.

We have been disobliging enough not to collapse and now we are in a tense struggle near the edge of a precipice where some provocation may prove too much of a push in the wrong direction. Again out of grandiose conceptions, overweening conceit, poor perspective and impatience with the cold war may come the last act. Finally, desperation over internal problems

can predispose to risk all on the throw of the dice of war.

We must, therefore, consider war with special weapons as a serious threat and prepare accordingly. Our military effort has, of course, been stepped up as the result of the hostile actions and provocations in recent years, and this acts as a deterrent. It can also be pointed out that a well arranged civilian defense acts in similar manner. The minimizing of damage, casualties and panic makes a vast difference in end results, and these in turn will influence the calculations of an enemy considering desperate ventures. The better our Civil Defense, the less likely we are to be obliged to use it in war.

So then, what is the enemy likely to attempt with special weapons and how is he likely to employ them? An answer to this in general terms can be derived from current knowledge.

You can read that the Russians have made and are making atomic bombs, including the hydrogen type; that they have had successful tests.

You can read that they are well up to the front in aviation and have long range bombers.

You can read that complete interception of hostile bombing planes is not possible.

You can read that they are well acquainted with Chemical Warfare including the nerve gases.

It is obvious that they must be familiar with the German type of guided missiles.

It is known that they have lots of submarines.

There is no reason to believe that they are neglecting Biological Warfare or Radiological Warfare.

Where does this leave us?

Well, as an enemy surveys the possibilities of a surprise attack, it would seem quite likely that he would decide to make it as heavy, overwhelming, and suddenly as possible. It would seem to his advantage to destroy and demoralize as much of our industrial and shipping capacity as possible in this first blow, before he might find himself handicapped by our retaliatory thrusts.

Since the greatest amount of destruction per plane is apt to result from "A" bombing, it is generally thought that primary emphasis would be on these weapons.

That appears valid and should be coupled with the idea that a number of bombs are likely to be used against large important targets. There is also reason to expect that some submarines built to handle guided missiles might be employed ~~to hurl atomic weapons at~~ against coastal cities.

This leaves us with Chemical Warfare, Biological Warfare, and Radiological Warfare. A complete evaluation of this would be too time consuming here and one can only say - don't dismiss them entirely from your minds. One or more of them can be employed along with atomic bombs to increase demoralization and impede rescue and rehabilitation. Mass casualties, too, are possible with Chemical Warfare. Radiological Warfare can have a great nuisance or harrassing value. Biological Warfare has possibilities and lends itself to sabotage.

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Coming now to the medical aspects we find our central problem is one of magnitude. Elaborate calculations have been made, based on Japanese records. These must be taken with realization that considerable variation is possible based on size and effectiveness of the bomb, time of day, type of weather, elevation of burst, types of structure, provision for prompt rescue and medical care, and finally, but far from least, advance warnings. Nevertheless, in any case the number of casualties will be huge. The usual estimate per "A" bomb in a populous city is 120,000 with about 80,000 surviving the first day and 60,000 surviving in all. This brings us to the need for a lot of special considerations which are worth highlighting:

<u>Clear designation of authority and workable organization</u>

<u>Adequate logistic planning and stockpiling</u>

<u>Well thought out local planning</u>

<u>Damage Control</u>. Special squads are often indicated, such as we have in the Navy and whose efforts have saved many ships and lives. Large industrial plants should consider this possibility.

Rescue. Special training for rescue crews is necessary to avoid dangers in working amid wreckage and rubble; also proper handling of casualties.

First Aid. Widespread instruction is needed - in fact it should be universal. What to do and what not to do also. Resuscitation methods have been improved and need to be taught. Usual first aid supplies in the home should be supplemented with a flash light, canned milk and food (several days supply), matches, candles, heavy gloves, rope. Sheets and blankets should be readily available. A sterno type stove is an excellent adjunct. Keep a few tools handy where they can be picked up readily.

Medical Supplies. These are listed in various books and brochures. A thing to remember is ample supplies for dealing with hosts of minor injuries. Proper treatment of these will prevent future complications and keep many more people available for duty.

Mutual Support From Adjacent Areas; Mobile Units

Transportation. All sorts of ambulances and conveyances should be available, but don't forget jeeps and helicopters, motor scooters and bicycles. Proper equipment for resuscitation and for clearing air passages should be part of all ambulance equipment.

Supplemental Hospitals. Schools are given first choice for more serious cases because of wide distribution and type of construction - few stories, large rooms, wide corridors and stairs, frequent presence of some type of commissary installation.

Hotels provide excellent accommodations but present difficulties on the score of possible elevator failure, narrow corridors and many small rooms. Individual survey will indicate value. They may often be out of commission due to concentration in the heart of the city where destruction is more likely.

Airport hangars may serve well as emergency field hospital sites.

Tent hospitals are often seriously considered. It should be remembered that tents deteriorate in storage, are laborious to set up and provide flimsy shelter.

Nerve Gases. These pose a very serious threat. Atropine is the principal remedy and must be given promptly and frequently. Severe asphyxia may develop in these cases and resuscitation measures need to be widely known.

Biological Warfare. This calls principally for alertness and ability to carry out prompt identification studies by laboratories. There is virtually no liklihood of epidemics being caused among our people. Our regular City and Public Health Laboratories can serve well and there is no need for panic.

Radiation. This falls within my own particular province and aside from that, involves so much confusion and misapprehension that I think I may dilate upon that subject with some profit.

In my lectures on radiological safety I like to note that there are perils both of over and underemphasis making one recall the Scylla and Charybdis myth. One finds grossly exaggerated fears based on serious

effects to be sure, but puffed up by wild stories and vivid imaginations and involving the possibility of serious panic, interference with important projects, wasted effort and needless expense. Some people are worrying about Geiger counters when they could more profitably think of how to deal with conventional perils. On the other hand, neglect of radiological safety has produced martyrs to science in the past, and is still producing victims of ignorance and reckelssness as well as accidents today. Serious problems in radiological defense are also involved and so let us evaluate that hazard a bit closely.

The Place of Radiation. The relative importance of radiation in causing casualties is usually estimated at 15 - 20 per cent as compared to 60 per cent for trauma and 60 per cent for burns. Obviously there will be many cases afflicted with all three and it appears likely that radiation as a complication has extremely adverse effects. It is apparent too, that since prospective casualties are roughly estimated at 120,000 for a bomb in a populous city, the immediate concern must be for rescue, first aid and care of shock, burns and ordinary trauma. The serious radiation effects come on later. This picture, of course, has reference to the type of explosion produced in Japan. If an underwater burst is used, the radiation problem will be of primary concern since there will be a deluge of water and foam laden with radioactive fission products. It is generally thought that air bursts are more likely since destruction is greater. An underwater burst is not likely to duplicate the extent and degree of contamination seen at Bikini, when we carried out such a test. This is because a considerable depth and a large volume of water are requisite. A convenient lagoon or its equivalent made to

order, is not conveniently at hand in many places. Nevertheless a nasty mess could be made to deal with where there are large harbors.

Reverting to the air burst it should be noted that although radiation caused 15 to 20 per cent of fatalities in Japan, it might have caused more if more victims had been rescued. Certainly there would have been more cases of radiation illness since it appears that 95 per cent of the survivors within a radius of 3,000 feet suffered in some degree from that cause.

Morale. In addition to the physical effects, it is worthwhile to note something of the psychologic. Commander Thomas A. Harris reached Nagasaki about a month after it was bombed, and reported to the American Psychiatric Association in a discussion, that the terror had by no means subsided and that the people had as yet not been able to pull themselves together and work effectively. They knew many were dying of radiation illness and very naturally feared for themselves. We can see in this that morale factors must be given the gravest consideration in our disaster planning and that they further emphasize the need for effectively coordinated relief from outside sources.

Coming now to radiological safety, it is interesting to note that in the early days of the century there was some little apprehension concerning the newly discovered x-ray and the rays from Radium, but, unfortunately, fears were largely absurd and misdirected. Scarcely anyone seemed to realize that there might be biological dangers. Instead, the public was treated to imbecilities. Thus, in the Pall Mall Gazette, it was stated: "We are sick of Roentgen Rays. It is now

said that Mr. Edison has discovered a substance - tungstate of calcium is its repulsive name - which is potential, whatever that means, to the said rays. The consequence of which is that you can see other peoples' bones with the naked eye - on the revolting indecency there is no need to dwell. It would be best to burn the works on these rays, execute the discoverer and whelm all calcium tungstate in the ocean. Let the fish contemplate each others' bones if they like, but not us."

In New Jersey, a congressman introduced a bill prohibiting use of x-rays in opera glasses. In London, x-ray proof underwear was advertised for women. Punch came out with a satirical poem to the effect that radiographers should leave people alone and confine themselves to spooks.

Thus there was plenty of ridiculous concern but very little sensible thought. It required quite a few years and many victims before good safety standards and satisfactory measurement units were established. The unit now employed is the "Roentgen" or simply "r". It is based on the production by the radiation of one electro static unit of ionization in one cc or 0.001293 gm of air. The upper limit of permissible dosage for generalized exposure has been set at 0.3 r per week of x or gamma rays per day (or the equivalent in effectiveness of other radiations).

It should be noted, however, that this dosage limit is for workers who are continually exposed to some degree of radiation in their daily occupation. It does not have practical application to occasional exposures. There is a pronounced tendency to confuse this type of work-

a-day standard with practical limits for occasional clinical exposures or those required for emergency or military necessities. The result is that there is much needless alarm and worry; also increased susceptibility to panic - a most important factor. Let us remember that we receive more than 0.3 r in many clinical applications of x-ray and radium - often much more. In the heavy exposures which might be involved in atomic warfare and related action, we think in terms of so-called calculated risk involving dosages extending from a few r to hundreds along lines about as follows:

Up to 5 r	negligible
Up to 50 r	of little importance: Possibly some mild effects
50 to 100 r	increasing incidence of minor disability; People still able to carry on
100 to 200 r	increasing incidence of illness: Victims likely to become casualties
200 to 600 r	increasing mortality. Serious and critical cases frequent. L.D. 50 at about 400-450
600 r + ...	Recovery unlikely

This applies to radiation received in the course of a few minutes or hours. When radiation is received over weeks and months, figures have a different significance and the total cumulative dosage can be greatly increased without severe effects. In certain diseases, 50 r of generalized body radiation have been given several times a week up to 500 r without alarming or dangerous radiation effects. However, it is considered that all exposure should be minimized and it is probable that about two hundred r of generalized or total body exposure is about

all that can be absorbed with relative impunity even in small increments such as 25 r weekly.

Time does not permit of much more elaboration but before closing a few points seem worthy of mention:

(1) In the case of an air burst, persistent radiation effects or fall out are of little or no practical concern in rescue work.

(2) In the case of contamination from underwater or underground bursts, it is to be remembered that the radiation from fission products although intense at first, diminishes rapidly, so that a delay of a few hours or even thirty to sixty minutes in emerging from shelters or entering contaminated areas will reduce exposure enormously.

(3) Radiological warfare is frequently mentioned in very serious and, at times exaggerated, terms. It sounds easy, in popular accounts, to make a city permanently uninhabitable but it is just not so. In addition, orderly evacuation from contaminated areas is readily possible. The greatest peril is that of panic, which could readily produce far more casualties than any Radiological Warfare agents.

In general, advantages relate to general harrassment, denial to an adversary of given areas or facilities for a time, interruption of work, possible production of panic, and frequent necessity for decontamination. Disadvantages relate to decay (limited half life) with resultant difficulties in stockpiling and need for constant renewal; difficulties in separating the most desirable fission products; shielding of personnel charged with responsibility of delivery; effecting adequate

concentration in the desired areas; diversion of pile function from production of fissionable materials.

This brings my rather sketchy coverage of medical problems to an end. I would like now to close with the reminder that huge as the problem is, there is much we can do and must do; that by so doing we will be prepared to save thousands of lives and at the same time aid in the prevention of war by disabusing enemies of the idea that we will easily be knocked out by "A" bombs or any combination of special weapons. A "pushover" is always a temptation for a bully.

We have taken tough knocks before and can take more if we have to. This time let us be ready.

STANDARD FORM NO. 64

Office Memorandum • UNITED STATES GOVERNMENT

TO :

FROM :

SUBJECT :

DATE:

The Atom Knowledge

Present Theory
of Popular Interest
& Confusing Statements

not as much contradiction
as ~~the~~ appears on surface
difference angle
capabilities
Possibilities
Probable Intentions

~~The~~ Commission deplored
that more info is not
made public ~~the~~ may
days are trying to liberally
[illegible] as much & rapidly as

possible. yet general
info recently available
gives a ~~sufficient clear~~ ~~fair / good picture~~
~~of the situation to indicate~~
~~that we should continue~~
~~by ourselves.~~
gives a fairly good picture

Page 5

RADIATION IN THE MODERN WORLD

Rotary Club, Charleston, S. C.

3 November 1953

RADIATION IN THE MODERN WORLD

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RADIATION IN THE MODERN WORLD

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The title for my little talk sounds, and in fact is, over-ambitious. The effort to cover the entire field would resemble an attempt to cover all of theology in a single sermon - a feat I heard one young Chaplain attempt some years ago, and naturally ~~with~~ very limited success. Thus I will limit my ~~field~~ talk to a highlights few points of interest relating to radiations that have just brought the world to some of its most stupendous problems and challenges - those that relate to nuclear energy and all that implies + high voltage apparatus.

Ionizing Radiation

These rays or radiations we term ionizing because that is one of the most important things they do, certainly in the human body. They may also disrupt or transmute elements- which is most important to the physicist. They comprise a rather varied lot including the X-rays, alpha, beta and gamma rays, neutrons, protons and electrons. + cosmic rays.

A technical account of these would surely not be appropriate here and what I hope to do is rather to put them in some sort of general perspective for you. Thus a little history becomes useful.

Roentgen's Discovery of X ray

Along about 1895 a distinguished German physicist failed to appear for his dinner much to his good frau's annoyance, as one can well imagine. It is likely that it wasn't the first time a good meal lost its savour while the preoccupied Herr Professor continued puttering about in his laboratory. On this occasion, however, there was an exceptional reason. Wilhelm Konrad Roentgen had just

discovered the X-ray.

Popular Reaction to X ray

The impact of this on both scientific and lay worlds was tremendous. X-ray promptly became the great wonder of the day and excited all sorts of curious reactions, including some that were humorous and some that were absurd. Punch produced a comic poem. Magazines showed grotesquely posed skeletons as examples of photographs by the new method. The Pall Mall Gazette wanted the discoverer executed on grounds of indecency. X-ray proof underwear was offered. A ban on the use of X-ray in opera glasses was desired by a New Jersey congressman.

~~Note~~ Lack of Concern for Safety

On the serious side a prodigious amount of research was done all over the world. In addition, natural radiation was investigated leading to the discovery of Becqueral rays and then Radium and Polonium. (These last the work of the Curies). Becqueral rays turned out to be a mixture of alpha, beta and gamma rays.

Bearing on Modern Physics

We have all grown up more or less familiar with X-rays and radium, but it is doubtful if many of us realize the important scientific implications and developments related thereto. That is natural because they were so technical and often theoretical. It was early realized that immense power was locked up in the atom. Einstein developed his energy mass equation in 1905, ($E = MC^2$) and trusted that radioactivity would one day prove it. ~~Our~~ The professor of astronomy in about 1912 in the Central High School of Phila was voicing the opinion that the energy of the sun was related to radioactive processes. I mentioned something about this in my own physics thesis in about 1914.

However, power and energy from the atom seemed a long way off - truly "pie in the sky" as we say today. We could see radioactive phenomena taking place right under our noses as in the spinthariscope or on our luminous dials, but there was nothing we could do that would influence the rate of energy emission in the slightest degree. You could do everything imaginable until ~~to the point of resembling the~~ efforts resembled those made on the ~~to expand the~~ magic skin ~~in one~~ of Balzacs famous story of the same name and with as little effect.

Nuclear Fission - Hahn & Strassman

Eventually, however, the key to the riddle was discovered, as it so happens, by workers who were looking for something entirely different. Hahn and Strassman in Germany were trying to build up new heavy elements in what we call the transuranic group, by shooting neutrons at uranium in hopes that some would stick. Well, when they came to analyze the results it became evident that something entirely unexpected was happening - so unexpected that the two scientists could scarcely credit it, and were very diffident about reporting the matter. What happened was that they found traces of lighter elements of such weight as to indicate that uranium atoms were being split up by neutrons (Krypton and Barium).

Chain Reactions

Now that doesn't sound very exciting to most of us but it was electrifying to physicists who realized the implications. These related to the chain reactions whereby neutrons split ~~large~~ heavy atoms which thereupon discharge more neutrons to split still more atoms. The details of this are naturally complex and need not concern us today other than to note that this process is associated with the fantastic energy releases we are all more or less familiar with as demonstrated in atomic bombs and nuclear ~~reactions.~~ reactors

Fusion Bombs

You may wonder now about the hydrogen or fusion bomb which would appear to be based on the opposite principle. Well so it is, but there is none the less a basic similarity. In the fusion of hydrogen & Lithium isotopes to form Helium, and in the splitting of Uranium or Plutonium to form lighter elements, mass disappears and energy is released in accordance with Einstein's equation already mentioned.

Thus by using, as it were, seven league boots we are up to nuclear weapons~~, and so let us see what radiation means in this regard.~~ Stop

Radiation ~~Sickness~~ HAZARD

You have all heard of radiation sickness and death in the case of the Japanese bombings. These resulted from gamma rays emitted at the time of explosion and from the fire ball and atomic cloud until they rose beyond range. This was something new, and very nasty ~~horridly spectacular what with loss of hair, prostration, and hemorrhagic and other pernicious effects~~ hemorrhages & infection. It naturally and properly aroused great attention and is still a matter for extensive research. However, in the preoccupation with this new entity there was for a while a tendency to overemphasize ~~an~~ radiation ~~effect~~ dangers in planning so that people were thinking too much in terms of running around with Geiger Counters, when there were far more ~~realistic~~ urgent things to do. Radiation may be expected to cause up to 15 or 20 per cent of the fatalities in an air burst type atomic attack. The effects will not be immediate nor call for first aid efforts; nor will there be significant radioactive contamination in any area where rescue operations will be needed. The contaminated area is small and limited to the zone of complete destruction. Thus the main immediate concern in an atomic attack will be for rescue, first aid

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and evacuation of burned and injured people. Later there will have to be provision for the radiation casualties and it will be well to remember that many apparently sound people from certain zones will be candidates. They should be kept track of and relieved from heavy work details. Radiation illness is greatly aggravated when exposure to inclement weather or heavy efforts have taken place during the quiescent interval.

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Underwater Burst

In the case of an underwater burst there will be far less fire and blast effect, but a deluge of radioactive water will complicate the picture. This radioactivity is very intense to begin with and quite dangerous. Nothing but prompt decontamination will save people drenched with such water. However, the radioactivity is due to very unstable fission products which decay rapidly, losing radioactive strength. The practical point here is that delay in emerging from sheltered areas or in entering contaminated areas becomes an important matter. Here is where monitoring teams can provide essential guidance. Delay of as little as one-half to several hours may be of great benefit.

Radiological Warfare

This type of danger also brings to mind Radiological Warfare. We can't dismiss the possibility entirely since it has possibilities of denying free access to certain areas, compelling evacuation or limitation of stay. It also has panic possibilities especially if a populace is not well informed.

It is not a particularly easy weapon to use and has its own drawbacks anent renewal of agents, stockpiling, danger to personnel delivering it and interference with normal pile operations.

Fall Out & newer Thermonuclear (H Bombs)

So much for weapons. Let us take a look at humane applications of Radiation.

Role in modern medicine

In recent years two features have captured the limelight. - Radio isotopes and supervoltage machines.

Isotopes

The present liberal supply of isotopes has been made possible by the atomic piles, or more scientifically - nuclear reactors. In connection with pile operation various fission products result and some of them, such as I^{131}, are useful. Again we put certain inert elements in the pile and let the neutron flux work on them. This produces transmutations or activations into radioactive elements. Finally some isotopes are produced in cyclotrons. Among the numerous isotopes which now come to about a thousand doctors are interested particularly in iodine[131] & P^{32} also Au^{198}, $Na24$, $Co60$, $Br82$; $Ga72$; $C14$ & others.

manner of action

The usefulness of radioisotopes is related to radiation effects. These elements act chemically in just the same way as their stable counterparts and are distributed in the same manner in the body. However, wherever they are, they continue to give out radiations, chiefly gamma and beta rays, one or both, like so many miniature X-ray machines or betatrons.

Selectivity Factor

What we would like, of course, is to have radioisotopes of such biochemical and physical nature as to go exclusively to diseased or cancerous cells and with the radiation strictly limited to them. Unfortunately they are not so obliging and there are always some undesirable general effects. The nearest approach to highly selective action is seen with iodine which, as most everyone knows, is particularly identified with the thyroid gland.

Limitations

In general there are distinct limitations and doctors must use them with great care and discretion, and with consideration of alternative or associated use of X-ray and other remedial measures. Special supervisory committees of experts in the fields concerned review cases in which isotopes are used. A high degree of expert knowledge and good equipment is necessary; also good technique.

Clinical Uses

Clinical use relates largely to certain blood diseases, cancerous conditions and over-activity of the thyroid gland - also to a few skin diseases, and finally to diagnostic studies by tracer methods.

Tracer Methodology

This brings us to another and very promising field: Research by tracers. In the past it has been very difficult to follow accurately the metabolic changes that take place in living tissues. It was as though we were trying to fathom the activities of a column of troops wending their way through a dense forest. And just as it would be easy to follow such a group if the members were continuously firing rockets into the air, so it becomes relatively easy to trace chemicals when elements are present that will shoot off various pyrotechnics in the form of radiations. Once more there are difficulties and limitations but the method is in general highly valuable, not only in medicine but in agriculture and industry.

High Voltage Apparatus

In the matter of high voltage machines, modern time ~~has~~ invention brought us cyclotrons and betatrons, synchrotrons, cosmotrons, linear accelerators, and others besides.

Energies now go into billions of electron volts. It sounds and is fantastic. They are ~~enormously unified~~ widely employed in nuclear research and are bringing some very practical benefits also. It might be noted that these machines although they differ very widely have this in common. They accelerate electrons, protons or other particles by repeated electrical boosts until these particles reach enormous velocities and energies. The voltages ascribed are meant to indicate the energy and are not actually present as differences of potential.

Betatron + x-ray - Place of Deep Therapy

In the medical world we are interested chiefly in the betatron varieties. These are electron spinners which make it possible to obtain X-rays up to 70 million electron volt energies + still higher; and also electron beams. Once more we cannot expect miracles from these, but I feel confident they will bring benefits to certain selected cases. You will probably wonder why. The answer lies in depth dosage factors - putting the dose of radiation where we want it and sparing other tissues - because you must remember radiation can be harmful. That factor of locating and localizing dosages is largely what is behind all our therapeutic maneuvering with isotopes and various types of apparatus. At all events low voltage X-ray affects the skin predominantly. As we progress to higher voltage the rays become more penetrating and more of the energy is absorbed within the body, and we get a preponderance of deep effects. Electron beams are not as penetrating as X-ray or gamma and are proving useful in skin conditions. Beta rays are composed of electrons and so beta emitting isotopes are often used for certain skin affections; in late years betatrons are being used for this purpose also.

limitations

As noted, these newer methods are promising, but I would like to point out again that there are limitations, that clinical evaluation is still not complete, and that the more conventional methods and apparatus still form the backbone of our radiation therapy, and a very excellent backbone. In other words, people do not need to feel that they ~~will be inadequately~~ cannot be properly treated ~~if~~ unless multi-million volt apparatus is ~~not~~ available for them, or the latest in isotopes.

Rad. Saf.

A word now on Radiological Safety. Atomic bombs and nuclear reactors have made us all conscious of this subject. I have already related something of that and so will only add: Let us not overlook the daily hazards or, on the other hand, exaggerate them. In general more serious attention is being given to the matter because:

1. The medical and dental use of X-ray continually increases.
2. Industrial uses of X-ray and radioactive materials increase steadily.
3. The use of radioactive isotopes increases steadily throughout the world.
4. More and more high voltage machines are being put in action.
5. It is recognized that there are harmful cumulative effects; these include Skin Effects; Blood Effects; Genetic Effects; Carcinogenic Effects; General effects on aging and longevity.

Now quantitative precision is far from what we would like in these matters, and in general very substantial dosages have been involved where significant harm resulted. Thus no one need be concerned about their clinical X-ray~~s~~ studies when, as is mostly the case,

they are under supervision of trained radiologists. At the same time it is well to avoid any needless exposure; and as for industrial application, survey of the situation by a radiation physicist is always advisable. Excellent standards have been set up and where they are followed workers are quite safe. It has to be remembered that effects may be quite insidious as we learned in the early days of radiation when enthusiasm outstripped discretion and when, of course, knowledge of the dangers was rudimentary.

Activities of the Armed Services

In closing I would like to mention that the Armed Services have been very active and interested in the field. As early as in the Spanish American War X-ray was put to use in the field. Excellent work was done in World War I, and in World War II the services pioneered in the use of photofluorograph for mass chest examinations; the Army employed 4 x 5 film and the Navy 35mm. These efforts helped greatly to speed the almost universal application of this method throughout the Country. The most popular size in this Country now is 70mm.

Research

In the matter of atomic warfare the medical servicees have done their part and I might note that important biomedical research has been done by us ~~also~~, that will prove of general benefit to humanity. Not all is sacrificed on the altar of Mars. We in the Navy have the US Naval Radiological Defense Laboratory at San Francisco and also do much work at the Naval Medical Research Institute, Bethesda, Maryland in the field of Radiology. A number of our larger naval hospitals now have isotope laboratories. A million volt X-ray machine is in

operation at St. Albans and a two million type ~~is being installed~~ has recently been put into operation
at Bethesda. Cosmic Rays are studied at Pensacola.

Training

Various books, brochures and manuals have been prepared, and we always stand ready to cooperate with our civilian colleagues to the greatest extent possible.

My personal thanks and those of the services for this opportunity to speak to you.

~~Lectures given ...~~

Papers & Lectures & Reports & talk

N.Y. - 1951-1953

informal talk USA Consultation - Canadian + American Staff Conference MHL

Jewish Hosp.

Manhattan Hospital

Community Church Group

A.E.C. Brookhaven

Delafield Hosp.

Brooklyn Hosp. Alumni

(8 or 10 times) Pere Flessage & Calc-Rads → Routine Lectures to S.W. classes

Read Sof. Group / CDRA } Developments in Radiology

Lectures to Radiology Eng Seminar

Lecture to Nav. Res. Seminar

Lecture Miami on isotopes (S.M.A.)

For P.E.R. Report { Paper on Casualty Estimates / Paper on R.W. & fire storm

Lecture on Med Aspects E.S.F. to Pub. Relations Officer E.S.F.

(not presented) → Paper on Civil Defense

Original For E.S.F. Compendium { Paper on medico-military Planning / Paper on Hospital Planning

Prepared planning compendium for E.S.F.

Revision Work for Atomic Med.

~~Talk to~~

Herman
Barnes
~~Gorrett~~
C. O. McAuliff
Funk
~~Ledbetter~~
~~Sounders~~
Miller ?
~~Gaither~~
F. H. ?
Col Smith

W Brown

Boatey
Simms
Munson
Rhatey
Pinwood

1 Barrel

$2500

~~G. forth~~ Asperin
A. P. C.

20

Radiation & the Modern World.

~~It~~ The Radiation & its Related phenomena have brought us fascinating & challenging problems. ~~[illegible]~~ — more than most of us realize for we are apt to think of the such matters as purely technical ~~& very~~ appropriately to ~~be~~ [illegible] ~~desiderata for the [illegible] physicists~~ to physicists & other scientific wizards as esoteric desiderata.

Nevertheless as is so often the case, matters of enormous importance ~~[illegible]~~ grow from inconspicuous beginnings much as the ~~genie~~ djinn of the Arabian nights came from a little bottle. Well that ~~little myth~~ fabled bottle held very potent spirits indeed but surely nothing like the potency deriving from the application of radiation.

In the very beginning late in ~~the~~ ~~[illegible] 1895~~ the ~~[illegible]~~ curious & beautiful glow effects in evacuated tubes aroused much speculation & before long we had X rays Becquerel Rays Radium & Polonium to deal with. A brand new type of physics developed & by 1905 Einstein had developed his equation relating mass & energy. ~~The theory of relativity was developed & soon~~ $E = Mc^2$. The old rigid theories of physics ~~collapsed, & it was soon~~ no longer could explain phenomena. ~~we found that our plain world a day hypotheses~~ ~~the~~ Our plain common ~~sense~~ ~~[illegible]~~ rationalizations became

inadequate. We found we spoke that in the minute
world ~~& universe~~ ses of ~~our~~ by particles & photons we must
~~translate~~ expand beyond our concept into mathematical terms we can't
visualize except in very rough approximation. We find
time & space interrelated ~~so~~ with that time constituting a sort of fourth
dimension. A four dimension geometry with curvature
of space explains gravitation & accounting for certain aspects of the Light rays or photons
~~show both~~ may act either as waves or particles; and in
turn particles themselves show wave characteristics
by means of which the electron microscope has become

planet Mercury which Newtonian astronomy ~~has so~~ failed to do

possible. We find that as the particles attain great speed
they increase in mass; that photon of light also have
mass. We find that we still are in difference as to the
fundamental nature of light, & electrons & other particles.
In connection with cosmic rays there are various types
of mesons ~~etc~~ & theories concerning them are still in a very
~~fluid~~ uncertain state. We find it difficult to pin down an
electron; ~~if you try to fix its position~~ the process of measurement
disturbs either position or ~~mass~~ momentum so we come to
Heisenberg's theory of uncertainty. We also ~~come~~ to deal with
statistical probabilities rather than fixed certainties. Our physicist

even come to the point of finding it easier to explain the positron (what is a ~~negative~~ positron) charged electron) on the basis of time going backward. In general the nice rigid precise, mechanical universe of a century ago has been replaced by much more flexible but also obscure & ~~uncertain~~ difficult concepts – which I think is a very good thing.

Until recent years what ~~relativity gave us~~ was ~~[illegible]~~

~~[illegible]~~

ATOMICS AND MODERN MEDICINE

(Atomic Medicine)

C. F. Behrens

Rear Admiral, Medical Corps,

U. S. Navy

Tri-State Medical Meeting, Charleston, S. C.
(Medical College of S. C.) 22 Feb 1954

Staff Conference, U.S. Naval Hospital, Charleston, S.C.
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ATOMICS & MODERN MEDICINE
Tri-State Med. Meeting

MEDICAL RESPONSIBILITIES IN DISASTER

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MEDICAL RESPONSIBILITIES IN DISASTER

Thank you for the opportunity to speak a few words on the subject of medical responsibilities in disaster.

We tend now-a-days to think of the subject as particularly modern and related almost exclusively to war, at least as far as civic concern is deemed necessary. We also tend to expect Red Cross and other federal agencies, including particularly the Armed Services, to step in and do the job in case of disaster, and as a matter of fact they do come to the rescue in generous measure. However, these efforts can well be supplemented by local activity - or perhaps one should say anticipated. Local agencies are the ones immediately available and needless to say promptness of rescue and aid are of the greatest importance. This audience, made up of folks with Armed Service background, knows that well. Our medical departments have bent every effort to bring prompt care to the wounded and effect early evacuation, often by helicopters. This has played a large part in the result that mortality has been reduced dramatically from 8.3% in World War I to 4.5% in World War II, and about half that in the Korean hostilities.

The same consideration pertains to casualties in peace time disasters. These strike all too frequently and pose sudden, severe and sometimes desperate problems. Just let your memory play over the past a bit and you will realize this very soon. Tornadoes, hurricanes, blizzards, earthquakes, volcanoes, fires, wrecks, floods, tidal waves, have taken heavy tolls. We can thus reflect that the planning and preparation recommended by our government in the matter of civil defense in war, will often pay good peace time dividends in lessening suffering, hardship and mortality.

The present day emphasis, of course, relates to possibilities of attack by special weapons and the value of preparedness is obvious from the standpoint of the care of casualties. Other considerations are also to be remembered. An effective civil defense will lessen emergency demands on the military, who will thereby be able to devote more energy to combatting the enemy. -- The demands apt to be made upon the Armed Services are well shown by the following excerpt from "Group Panic and Other Mass Disruptive Reactions":

"In the Texas City disaster, the explosion of the French ship, S.S. Grandcamp, occurred at 9:10 a.m., 16 April 1947, and 20 minutes later the nearest Army installation, Fort Crockett, near Galveston, was contacted for aid. 'At the request of the local sheriff's office, the Commanding Officer, Fort Crockett, suspended normal operations at 0930 and dispatched all available personnel, both military and civilian, to Texas City with the primary mission of evacuating injured to Galveston.' Furthermore, "The Army assisted the Red Cross by continuing to rescue, feed, house and administer medical aid to civilians of the stricken area until 22 April. The Army supplied over 200 doctors and nurses, medical supplies for 5,000 victims, operated 2 food kitchens serving 2,000 meals daily, plus 2 dock area canteens serving coffee and sandwiches, operated 2 refugee camps with a total of 5,000 person capacity and supplied equipment for all the above plus food for the first 2 days. Engineer, Quartermaster and other supplies including numerous trucks and ambulances, were provided and radio communications were forwarded by Fourth Army Signal Section. Army aid was withdrawn gradually as the Red Cross and civilian agencies' needs decreased and Army activities ceased on 26 April 1947.'

"Less than 12 hours after the beginning of the Detroit 'Bloody Week' race riot in 1943 (a war year), aid in controlling the riot was sought from the Army. '.... Mayor Jeffries telephoned Governor Harry F. Kelly ... and asked that Federal troops be summoned. The Governor transmitted this plea by telephone to Sixth Service Command Headquarters.'

"The point in citing these examples (and numerous others could be mentioned, as well as citing those in which the Navy worked with the Army or those in which the Navy alone played a supportive or predominant role) is to show that the Armed Forces are from time to time called on to render aid to civilian populations which are unprepared to cope with major disasters. Plans for dealing with disasters including the prevention and control of panic should be developed for all civilian communities so that aid from the Armed Forces during disaster will not be required. The facilities of the Armed Forces will not then need to be diverted from other missions in time of war or national danger. 'The fear reaction of the uninitiated civilian is ever evident. It is of such magnitude that it could well interfere with an important military mission in time of war.'" (Gen. Cooney in Rad. Def. Vol III) (Excerpt taken from "Group Panic and Other Mass Disruptive Reactions", by John M. Caldwell, Col., MC USA and others published in U.S. Armed Forces Medical Journal, April 1951)

In addition to lessening emergency demands on the military, the presence of an effective Civil Defense should serve to diminish the seductiveness of any attack by enemies. Even such activities as seeking shelter or accomplishing evacuation of various areas require thought, planning, experiment and practice if confusion, panic and clogging of thoroughfares to be prevented. Simply, knowledge, indoctrination and a spirit of confidence will go a long way in preventing such tragic results as resulted from the broadcast extravaganza of "The Invasion from Mars", H. G. Wells' story of the War of the Worlds. You will recall that many people in New York rushed out in panic stricken flight on that occasion. In a foreign country the broadcast was repeated with similar effects except that when it became known that a hoax had been perpetrated, a mob wrecked the station or newspaper concerned. There is nothing like ignorance, fear or obscure dread, and lack of preparedness to produce panic. On the other hand, education is the best preventatives. Accordingly something worth while can be done in the matter of defense against disaster, no matter how limited the funds. Various societies and discussion groups can take advantage of a very abundant literature to inculcate knowledge. This has been the policy of our various medical societies and I am glad to say they have taken very effective interest. However, much remains to be done and the professional groups need ample and diversified assistance.

I am glad, therefore to see that your organization is retaining an interest in a subject relative to our Civil Defense. Most of us want to forget it. It spells time and trouble and occasionally, at least one hopes, uncomfortable pricking of the conscience.

That of course is the story for all preventive measures. As I pointed out recently to our own people in the matter of food handling regulations, we are all far more prone to take chances than to take trouble. In the matter of special weapons we find several factors which especially augment this tendency and the spirit of apathy. We have had no personal experience with bombing ravages in this country and so the matter takes on an aura of unreality. Again we are an optimistic people and tend to feel that these horrors so often depicted simply can't happen here. Then finally we encounter a feeling that even if nuclear weapons should be employed against us it would all be so overwhelming that it is not worth while attempting to do anything about it.

These aspects have been further aggravated by a tendency toward all or nothing reactions. For instance, it was early realized that decentralization of industry would greatly diminish the effectiveness of an attack by special weapons. However, someone got busy with pencil, paper and calculations and came up with a total cost of something like 300 billion dollars, and to make it worse the pprocess would cause gross disorganization of industry. So it seems that in effect

everyone threw up his hands in the familiar "What's the Use" gesture. At all events although there has been increased industrial expansion beyond metropolitan centers, there has been still more expansion within. Thus we have lost ground. If a reasonable program could be started, very valuable progress could be made gradually and without very painful efforts or costs, and with considerable gain on the score of lessened urban congestion - which as we all know, is coming to be a veritable modern curse.

Again it is likely to be assumed that if we don't have lots of money little can be done and so nothing is done, particularly in cities where it is assumed that they are not likely targets and so wouldn't be concerned except indirectly and remotely. As to the first, it can be said that plenty can be done with little or no money - instructions in first aid and rescue techniques; organization of mobile support units; instruction in fire fighting; plans for transportation; plans for control, i.e., establishment of authority at the scene of trouble. As to "target" considerations, communities should not be too modest. Most authorities, as a little reading will indicate, believe that if we are to be hit at all, it will be in an "all out" effort to completely demoralize the whole country; and cities which escape bombing will surely have very important roles to play in support and mutual assistance.

Coming now to some details, I think you have all seen general estimates of damage and casualties in various articles in popular journals and some of you may have dipped in to the "Effects of Atomic Weapons" and other scientific books.

Thus I will not say much into these general aspects. Instead I would like to give you the gist of a study made by Mr. John McCullough of the Delaware Valley Port authority and presented in a communication from Civil Defense Research Associates of which organization I have been a member. This study endeavors to bring the details of atomic bomb effects on a large city (Philadelphia) into clearer focus. It probably means more to me than most people because Philadelphia happens to be my old home town, but I think most anyone can gain something from the study because the picture would be roughly similar in many of our other cities.

It reflects the study of a test made October 6, 1953. Mr. McCullough states what "happened" in the following terms:

South Philadelphia would be burned out and in the areas of complete destruction and major damage there would be the following

1301 physicians' offices and many of their homes;

2324 attorneys' offices and many of their homes;

17 hospitals;

119 retail drugstores and their suppliers;

45 churches;

185 clergymen;

43 schools;

23 banks and branch offices of banks

722 retail and wholesale food establishments;

226 inflammable businesses - lumber yards, junk yards, paint shops, hardware stores and the like;

77 gasoline stations and fuel oil distributors;

55 hotels;

20 theatres;

4 large nurses' homes;

12 newspapers;

4 radio stations;

10 state liquor stores.

"It is not possible to explore all of the consequences of the attack - to unravel out to its last bitter thread the skein of the catastrophe. Perhaps it isn't even necessary.

"But it must be clear beyond any question that this is not merely an effect upon Philadelphia, nor upon its valley, nor upon its state. Its impact is national, even international.

"Because one small block of Philadelphia's "Maiden Lane" on Samsom Street lies in utter and total ruin, the jewel merchants of Amsterdam and Johannesburg and Calcutta are summoned to excited conferences. Because some offices along 2nd and 3rd Streets have been incinerated, there is consternation in the wool markets of Australia.

"Can any one of us even remotely imagine the chaos resulting from the destruction in a micro-second of all of the papers and the records of 1300 attorneys - even if every attorney, every briefing clerk, every stenographer and telephonist physically survived? The records that men live by, that make it possible for a society to pursue its normal course - burned to ashes, blown to the four winds or buried inaccessibly perhaps forever, beneath debris.

"Can you imagine what chaos would greet the grim dawn of the 7th day of October? It is only then that we would begin to sense the

enormity of the disaster. What would our complex economy do with its bank credit shattered, its commercial paper inaccessible? What the many persons living upon annuities whose urgent requirements could not be met because the heart of the financial district was a heap of smoking and jumbled masonry?

"The very ships at sea would radio their owners frantically, asking for new orders - for their consignees are gone, the banks which advanced them credit, the insurers who insured them, the very stevedores who would unload them - gone in the holocaust."

All of this is surely grim but the grimmest situation can be made less grim if we are prepared. And as already pointed out that this type of preparedness pays valuable peace time dividends and the lack of it spells needless loss and suffering.

The medical records of recent years indicate that in various instances of tornadoes, fires and explosions we could have profitted greatly by better organization and general preparedness.

From the medical standpoint our problems sum up about as follows:

1. Rescue and First Aid. Needs will be on a vast scale. This calls for virtually universal knowledge of at least the rudiments of what to do and what not to do. The Red Cross has often been of great help in providing first aid instruction. It needs to be remembered too that the rescue of people from ruins is not something to be rushed into blindly by the ignorant and untrained.

A good many communities now have one or more rescue units and in general they have proven excellent investments.

First aid instruction should include some reference to Chemical Warfare, particularly with nerve gases, and indoctrination in more basic aspects of Radiological Safety, Radiological Warfare, Biological Warfare. Modern methods of resuscitation take on considerable importance since severe nerve gas poisoning eventuates in respiration paralysis. Nerve gases, it might be noted, are really extremely poisonous liquids which readily form aerosols and can be absorbed through the intact skin as well as by inhalation or swallowing contaminated food or drink. In the eyes they produce painful ciliary spasms and contracted pupils; watery nasal discharge appears; breathing becomes difficult and in the end there are convulsions and respiratory paralysis. Atropine is the proper antidote and must be given early and in vigorous dosage. It is of interest to note recent reports that a synthetic product is now becoming available.

2. Triage and first aid stations. You will find them described in Civil Defense literature. They play an important part. If properly equipped to handle the vast multitude of minor injuries they can prevent unnecessary overloading of hospitals. Again by keeping in touch with central controls and hospitals, patients can be distributed to best advantage. This involves control and authority also; and in the absence of such, experience shows that there will be a bad pile-up in some places while others get few cases. Spur of the moment decisions in the midst of disaster conditions and in the absence of previous thought and planning are likely to take on panic characteristics, and contribute to confusion.

3. Emergency hospitals will be called for.

4. Expansion of regular hospitals by increasing beds and discharging or transferring less urgent types of cases.

5. Plans for streamlining medical, surgical and laboratory procedures to care for the large influx of patients to best advantage. One of the greatest problems of all is that of sheer magnitude.

6. Arrangement for transportation.

7. Selection and organization of teams for use in the hometown or for aid elsewhere.

8. In the matter of Biological Warfare defense, the backbone is our U.S. Public Health laboratories together with the state and local facilities and also agricultural units. It must be remembered that attacks may well involve crops and domestic animals. On the reassuring side it is considered that our Public Health status and the availability of remedial measures are such that extensive epidemics among our people should be preventable.

9. In the matter of radiological hazards the need is more for elucidation to prevent panicky fears and at the same time lay the ground work for appropriate preparations and precautions.

10. Public Health Problems. These are manifold and you will find a good discussion of them in Volume 68, No. 11, (Nov. 1953) of the U.S. P.H.S. reports. They touch, of course, water, food, sewage disposal, preventing epdiemic disease, providing shelters for refugees, insect and rodent control, household sanitation, disposal of the dead.

11. Provision for psychiatric casualties and measures for panic prevention.

12. Plans for mobile support to other communities. (See also 7).

This about covers the high lights as much as possible in a short discourse. In closing I would like to leave the impression that although the possibilities are grim in the extreme, we need not take dispairing defeatist attitudes. There is much we can do; and do it as we go without one might say "busting our buttons." At the same time the sense of urgency must not be lost otherwise we are likely to revert to our traditional habit of filing away or junking our plans, scrapping our organizations and reverting to a good old Rip Van Winkle snooze.